BOOK 3
DETAILED
SPECIFICATIONS PART 3 OF 3
(Divisions 31 thru 34, Appendix)

DAMEN GREEN LINE STATION

CDOT PROJECT NO.: D-7-135

SPECIFICATION NO.: 1186934

CITY OF CHICAGO

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DEPARTMENT OF PROCUREMENT SERVICES

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All Signatures To Be Sworn To Before A Notary Public

Any contract entered into as a result of this bid process is governed by the terms and conditions set forth in Book 1 "Terms and Conditions for Construction" for CDOT projects funded by the City, as amended and incorporated as if fully set forth here by this reference; and by Book 2, Book 3 (if applicable), plans, drawings, exhibits, and attachments as appropriate.

SECTION 31 09 13

MONITORING TRACK STRUCTURES DURING CONSTRUCTION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1, "Terms and Conditions for Construction" and Book 2," Instructions and Execution Documents and Additional Special Conditions," apply to this Section.

1.02 SUMMARY

A. Purpose: The work associated with this specification requires the Contractor to monitor construction activities and monitor track structure that is susceptible to damage resulting from construction activities. This includes, but is not limited to, the following:

1. Installation of surrounding excavation support systems may result in ground movements around adjacent structures. Ensure that ground movements are within acceptable limits so that there is no increase in likelihood of damage to adjacent structures.
2. Adjacent structures and ground movements adjacent to open cuts or embankments are within acceptable limits so that there is no increase in likelihood of damage to adjacent structures.

B. Scope: The work includes, but is not limited to, furnishing, installing, calibrating all necessary equipment, developing monitoring software, establishing survey points, and all necessary equipment and materials for a complete monitoring system, including qualified personnel with experience and training to implement, review, assess, and draw conclusions on data generated by the monitoring system.

C. A summary of the work described with this Specification includes, but not limited to, the following:

1. Identify Extent of the Project.
2. Perform Preconstruction Document Review.
3. Perform Preconstruction Condition Surveys.
4. Evaluate track structure.
5. Develop Response Values and contingency plans.
6. Perform interim construction surveys that include monitoring, collecting, and reporting instrument data.
7. Perform post-construction condition survey.

D. Monitoring system includes, but not limited to, the following: Install slope inclinometer. Qualified personnel shall include and meet the minimum qualifications herein.

1. Contractor's superintendent that has experience supervising a minimum of ten site vibration
2. Monitoring programs of equivalent size and complexity to this project.
3. A field instrumentation specialist(s) that has a minimum of 5 years' experience using every piece of monitoring equipment used on this project and is a licensed Professional Engineer or Surveyor in the State of Illinois.
4. The Contractor's Engineer (SSE) shall have a minimum of ten site vibration monitoring programs of equivalent size and complexity to this project. The Structural Engineer must sign and seal all submittals related to this Section.

E. Division of Responsibility: The Contractor's superintendent is responsible for overall coordination, delivery of field reports, acceptable working limits, and the decision to perform work based on monitoring data the Contractor's team collects. Furthermore, the Contractor is responsible for providing and maintaining access to instrument locations throughout construction. Reporting to the Contractor's superintendent; the field instrumentation specialist(s) are responsible for providing, installing, and obtaining data from the ground instrumentation and from the structural instrumentation, and the Structural Engineer is responsible for identifying the risks to the track structure, setting the acceptable working limits, and verifying that temporary conditions are engineered to sufficiently meet the acceptable limits.

F. Adjacent Properties: The Contractor is to meet the requirements for the protection of adjacent properties from the construction of temporary shoring, earth retention systems according to Specification 02 16 10, Monitoring Adjacent Structures During Construction Activity.

G. Related work specified elsewhere:

1. Section 02 16 10 – Monitoring Adjacent Structures During Construction Activity.
2. Section 31 20 00 – Earthwork.
3. Section 31 50 00 – Excavation Support and Protection.
4. Section 31 63 33 – Steel Pipe Micropiles.
5. Section 31 63 00 – Caissons / Drilled Piers.

1.03 DEFINITIONS

A. Definition of project terms and abbreviations are found within Specification Section 01 35 00.

B. Definition of terms are found within Specification Section 01 35 00.

C. The Project = includes the new train station, pedestrian bridge, North Side access, CTA track structure, and portions of property within the City of Chicago Right of Way and under CDOT control near the intersection of Damen Avenue and Lake Street. Refer to drawings for more information.

D. CTA-ACM = Chicago Transit Authority Adjacent Construction Manual Rev 00, September 2017.

E. Adjacent Structures = Include (1) structures adjacent to the project that may be affected by construction of the project including, but not limited to, structures that may be affected by vibrations, displacements, settlement, excavations, demolition, or other construction activities; (2) structures including, but not limited to, buildings, roads, utilities, and infrastructure deemed important enough for monitoring; (3) any

building or structure not owned by the CTA, and any building Owned by another City of Chicago agency, and (4) any relevant structure that is expected to be in place prior to completion of the work on the Project.

F. Track Structures = Includes all structures owned by the Chicago Transit Authority (CTA) including, but not limited to the new and existing train track supporting superstructure and sub-structure both within the Project boundaries and outside the Project boundaries. In addition, this includes the new train station, pedestrian bridge, and North Side access.

G. Response Values = Threshold Values and Limiting Values.

H. Threshold Values = A performance-based monitoring unit, predetermined by the Contractor for a specific type and location of monitoring. The Contractor must incorporate corrective actions into its construction means and methods to avoid reaching the established threshold value. The threshold value will be determined by the Contractor using current industry standards and recommendations, and will consider the type, age, condition, and sensitivity of the Adjacent Structures to minimize serviceable damage. The CTA-ACM denoted Threshold values as Warning Values.

I. Limiting Value = A performance-based monitoring unit, predetermined by the Contractor for a specific type and location of monitoring. The Contractor must stop work immediately upon equaling or exceeding a limiting value. The limiting value will be determined by the Contractor using current industry standards and recommendations, and will consider the type, age, condition, and sensitivity of Adjacent Structures to protect a structure or utility from unacceptable levels of distress.

J. Cased Deep Benchmarks = Benchmarks founded at an elevation below the bottom of the excavation and which are isolated from the surrounding soil by an outer casing. Cased deep benchmarks are used as control benchmarks for determining the elevation of all other instruments.

K. Surface Settlement Markers = Markers placed on structures and monitored using optical survey methods to determine vertical and horizontal displacements during construction.

L. Inclinometer Casing = An instrument installed within vertical holes located entirely in the in situ soil. A probe lowered within the inclinometer casing is used to monitor horizontal displacements of the soil behind the Temporary Earth Retention Structures at depth during construction.

M. Tiltmeter Plates = Instruments installed on structures to monitor angular rotation of the structure during construction. The plates are monitored by placing a portable tiltmeter on the plate.

N. Vibrating Wire Strain Gages = Gages installed on horizontal struts (or track structure with written permission from CTA) to monitor the load in the struts during construction. The strain gages are read with a vibrating wire indicator.

O. Crack Monitoring Pins = Two pins; one pin placed on each side of a crack that can be measured with calipers to determine accurate changes in crack dimensions.

P. String Potentiometers = Cable-actuated position sensors that locate a specific ground position in one or more directions.

Q. Vibration Monitors = Seismograph equipment that accurately monitors ground movements (accelerations, velocities, and overall movement).

R. Settlement Indicators = Equipment set up to measure and record the elevation at the top of soil of a specific location. Repeated readings at the same precise location would provide indication of settlement (lowering elevation of the top of soil).

1.04 REFERENCES

A. Chicago Transit Authority Adjacent Construction Manual (CTA ACM) Rev 00, September 2017, applicable Sections as specified in this Specification.

B. Geotechnical Report by GEI, Inc.

1.04 SUBMITTALS

A. Resumes of the qualified personnel previously listed (Contractor's Superintendent, all field instrumentation specialists needed, and a structural engineer), and other key personnel, detailing relevant experience and qualification as noted within Section 1.3.

B. Product data for all monitoring equipment used including measurement range, resolution, repeatability, accuracy and precision, temperature range, etc., as applicable for individual equipment.

C. Drawings and details showing proposed physical locations of instrumentation indicating layout and instrumentation installation details. The plan must show the instrumentation in relation to nearby:

1. Existing track structures and supporting foundations with bent identification numbers.
2. Shoring structures to be installed.
3. Any installations for protecting shoring structures.
4. Surface and subsurface infrastructure.
5. Proposed limits of excavation support walls.
6. Proposed limits of sloped open cut excavation.
7. Limits of adjacent private properties.

D. Preconstruction Condition Survey:

1. Perform a detailed survey of the Track Structure including, but not limited to, the following:

   a. High-resolution photography.
   b. Visual exterior condition assessment.
   c. Visual condition assessment of any track structure uncovered during the work.

d. List all documents reviewed in preparation for the preconstruction condition survey.

2. List how the probable means and methods of construction planned for the Project may adversely affect the visually observable systems previously described.

E. Response Value Summary Report:

1. Using the information gathered in the preceding tasks, evaluate potential impacts on the Adjacent Structures from construction-phase activities including, but not limited to, post-construction ground or structure movements associated with the design, construction-induced vibrations, and excavation-induced ground movements using published literature and empirical correlations. Perform this evaluation using a licensed Structural Engineer in the State of Illinois. Report shall include, but not limited to, items below for each risk identified:

a. Level of structural and nonstructural risks associated with anticipated construction activity.
b. Instrumentation recommended to monitor each risk.
c. Frequency of measurements taken during construction from the instrumentation noted above.
d. The limit state values (Threshold Value and Limiting Value) associated with each measurement taken during construction.
e. Contingency plans the Contractor will perform in the event the Limit State Values are exceeded.

2. Include the following information:

a. Name(s), telephone number(s), and location(s) of person(s) responsible for implementation of contingency plans.
b. Materials, equipment and supplies required to implement contingency plans.
c. Location at work site of all necessary materials, equipment, and supplies required to implement the contingency plans.
d. Each type of anticipated remedial method proposed to stabilize soil and/or structure movements. Include basis for determining proposed actions.
e. Step-by-step procedure for performing work involved with contingency plans.
f. Clear identification of objectives of contingency plans and methods to measure success of contingency plans.
g. A field monitoring plan that contains a detailed step-by-step procedure for conducting and reporting all monitoring measurements to include, but not limited to, the following:

1) A schedule indicating the proposed time sequence of instrument installation.
2) Field validation plan and summary report of the results as specified in Part 3 – Installation of Instruments.
3) A schedule complying with required monitoring and reporting frequencies, for all instruments and monitoring points.

4) Types of monitoring instruments with manufacturer's data sheets, including calibration reports and maintenance procedure requirements. Calibration reports will include the initial calibration procedure, all recalibration dates and procedures, and regularly scheduled recalibration that is necessary.
5) Data survey methods for optical surveys necessary to demonstrate that the specified accuracies can be achieved at a minimum 95% level of confidence.
6) Data processing procedures.

h. Reporting procedures for scheduled reports and for special reports when Threshold Values and Limiting Values are being approached and are exceeded.
i. Submit a contingency plan for the eventuality that each individual, and/or likely combinations of threshold values are reached, for approval.
j. Outlines of sample reports and processed data forms.
k. Processed data as specified in Part 3 – Data Collection and Processing.
l. Descriptions of the monitoring equipment that meet the requirements as specified in Part 2 – Products.

3. Submit all of the above at least 6 weeks prior to start of excavation work. An agreement is to be reached between the CSE and the Contractor's Superintendent on the contingency plan to be utilized for stopping further movement, prevention of additional damage, and corrective actions.

F. Post-Construction Condition Survey:

1. Perform a detailed survey of the Track Structure that duplicates the process performed during the pre-construction survey.

a. Perform the survey within thirty calendar days after Substantial Completion of the project.
b. Identify any deviations from the preconstruction condition survey. The post-construction surveys will be used to evaluate if the Project construction activities caused damage to the Adjacent Structures.

1.06 QUALITY ASSURANCE

A. The Contractor employs the services of the qualified personnel specified within Section 1.3.

B. Prior to the start of construction, the Contractor meets with the Commissioner to discuss the Preconstruction Condition Survey, Response Value Summary Report, and a field monitoring plan.

1. The Contractor provides access to instrument locations and prevents construction activities that would damage ground instruments during construction.

C. The Contractor ensures that the field monitoring schedule of reports (established within Section 1.5.6) is followed.

1.07 JOB CONDITIONS

A. Existing site geotechnical conditions have been investigated and a report prepared by GEI, Inc. This report is in the appendix of these Specifications. Neither CDOT nor their representatives are in any way responsible for the safety and serviceability of the work. The Contractor, and their Structural Engineer, are expected to make his own interpretations of the data for their own purposes. Furthermore, the General Contractor must install, monitor, and interpret data from any additional instrumentation that the General Contractor deems necessary to insure the safety and serviceability of the work.

PART 2 - PRODUCTS

2.01 EQUIPMENT

A. The Contractor shall use any and all equipment they deem necessary to carry out the work described within this specification. The General Contractor is solely responsible for the determination, acquisition, installation, maintenance, replacement, and operation of all equipment.

PART 3 - EXECUTION

3.01 PROJECT ACCESS AND SCHEDULE

A. The Contractor shall permit Project access to the Commissioner and any representative identified by the Commissioner.

B. Approximate Project schedule is denoted on the drawings.

3.02 AVAILABILITY OF DATA

A. Do not disclose instrument-monitoring data to third parties and do not publish instrument-monitoring data without prior approval of the Commissioner.

B. The General Contractor is expected to make their own interpretations of instrument-monitoring data for their own purposes.

C. The General Contractor may observe equipment readings at any time (but as a minimum during the preapproved scheduled times), or take supplementary readings at no additional cost to the Commissioner. All data collected by the General Contractor must be made available to the Commissioner.

3.03 INSTRUMENT INSTALLATION, PROTECTION, MAINTENANCE, AND REPLACEMENT

A. Protect and maintain instruments. Drain water or flush debris from under protective covers. Keep protective covers locked.

B. Provide approved substantial protective barriers as required around cased deep benchmarks and around subsurface settlement indicators.

C. Repair or replace damaged or missing instrument components or entire instruments as required within five days at no additional cost to the City of Chicago.

D. The location of the instruments will be per approved submittal.

E. Installation of any instrument shall not damage or interfere with existing utilities and shoring structures. Contractor shall design, install, and protect displacement monitors from accidental movement or damage from snow plows.

3.04 DATA COLLECTION AND PROCESSING

A. The contractor is solely responsible for creating the validation plan. This plan shall clearly show that the appropriate equipment and qualified personnel were used to successfully complete the track monitoring plan.

B. Validation of Equipment and Crew: The installed monitoring system, each component thereof, is to be field certified for the accuracy and reliability required for the Threshold and Limiting Values.

C. The following are items mandated by CTA for data collection and processing:

1. The processed survey data will be submitted on a similar form as shown in Appendix E in CTA ACM.
2. For excavation within the Zone of Influence as specified in Section 3 of CTA ACM, monitoring frequency specified in CTA ACM Section 10.3 will be followed.
3. For earth retention structure or drilled shafts adjacent to CTA tracks, the survey points shall comply with Figure 10- 1 in CTA ACM, unless otherwise directed by the field instrumentation specialist that more survey points are required. For shoring structures directly supporting elevated track structures, survey points must be on the shoring structure and the elevated track structure component that the shoring structure is supporting.

D. The following are items mandated by CTA for defining and submitting Threshold and Limiting Values:

1. Threshold Values and Limiting Values as specified in Section 10.2 of CTA ACM for CTA tracks.
2. Limiting Values as specified in Section 7.9 of CTA ACM for top of shoring wall within the Zone of Influence of CTA tracks.
3. Temporary shoring within the zone of influence for highway or street is coordinated with the governing agency.
4. The Contractor is responsible for adhering to the Threshold Values and/or Limiting Values as defined by each governing agency or Authority or utility owner having jurisdiction.
5. If a Threshold Value is reached:

    a. Notify Commissioner and CTA within 12 hrs.
    b. Perform Supplemental Monitoring to measure rail movements and cross-slope under dynamic loading using pumping gage as specified in Section 10.4 of CTA ACM.
    c. Within 24 hrs of monitoring data indicating that a Threshold Value has been reached, implement contingency plans per approved submittal.

6. If a Limiting Value is Reached:

   a. Notify Commissioner and CTA within 8 hrs.
   b. Within 12 hrs of monitoring data indicating that a Limiting Value has been reached, implement contingency plans per approved submittal.

3.05 REPORTING DATA

A. Formal monitoring reports will be submitted within five working days of retrieving the raw data. Raw data is made available to the CTA within one working day of reading when requested. The Contractor may observe the readings at any time (but as a minimum during the preapproved scheduled times), or take supplementary readings. The Contractor is responsible for the safety and serviceability of the work. The Contractor is to make interpretations of the data for the purposes of monitoring for any movement. Do not disclose instrumentation data to third parties. Do not publish data without prior written approval of the CTA.

3.06 DAMAGE TO INSTRUMENTS

A. Take precautions during the course of construction to prevent damage to instruments and monuments. Pay all costs associated with restoring damaged instruments.

3.07 DISPOSITION OF INSTRUMENTS

A. Remove all structural instrumentation at the conclusion of the monitoring effort. Ground instrumentation is disposable and will remain in place. Cavities for in-ground instrumentation are to be filled with an approved material.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The work of MONITORING TRACK STRUCTURE DURING CONSTRUCTION shall not be measured for payment.

4.02 PAYMENT

A. Payment for the Work of MONITORING TRACK STRUCTURE DURING CONSTRUCTION is included in the Contract lump sum price as shown in the Schedule of Prices for CIVIL WORK.

B. In the event that any submittal is not sufficient for approval by the Commissioner, the Contractor shall supplement their track monitoring plan with the necessary instrumentation, personnel, and labor sufficient to obtain approval at no extra cost to the Commissioner.

4.03 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 02 00 00.

END OF SECTION

SECTION 31 15 00

SHORING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions, apply to this Section.

1.02 SUMMARY

A. This Section specifies requirements for temporary shoring of existing rapid transit structure, buildings, and other construction and structure during demolition and construction operations. The work under this section shall include all labor, material, tools, and equipment required to provide and install temporary support for the structures to facilitate removal, relocation, repair, additional new structure and related work as shown on the drawings, specified herein and directed by the Commissioner.

B. Related Sections: The following sections contain requirements that relate to this Section.

1. Section 02 16 10 – Monitoring Adjacent Structures During Construction.
2. Section 02 41 16 – Structure Demolition.
3. Section 02 41 19 – Selective Demolition.
4. Section 03 30 00 – Cast-in-Place Concrete.
5. Section 03 33 00 – Cast-in-Place Architectural Concrete.
6. Section 03 41 00 – Precast Concrete Platform.
7. Section 05 10 30 - Structural Steel.
8. Section 05 31 13 – Steel Decking.
9. Section 05 51 10 – Stainless Steel Floor Panels and Stair Treads.
10. Section 06 15 43 – Mass Timber Panels.
11. Section 31 09 13 – Monitoring Track Structures During Construction.

C. Definitions:

1. Definition of project terms and abbreviations are found within Specification Section 01 35 00.
2. Temporary shoring shall include furnishing all steel, cribbing, leveling screenings, grading, and erection.

1.03 REFERENCES

A. Acronyms for reference standards are defined in Section 01 42 00.

B. IDOT SSRC Standard Specification for Road and Bridge Construction, adopted January 1, 2012, including the current Supplemental Specifications for these sections.

C. American Railway Engineering and Maintenance-of-way Association (AREMA) "Manual for Railway Engineering."

D. ASCE 37 Standard for design loads on structures during construction.

E. Chicago Transit Authority Adjacent Construction Manual (CTA ACM) Rev 00, September 2017, applicable Sections as specified in this Specification.

F. Geotechnical Report by GEI, Inc.

1.04 QUALITY ASSURANCE

A. The Contractor is solely responsible for the design of shoring systems. All shoring shall be designed and have calculations performed according to the items noted within the Submittals Section C of this specification and the drawings. In addition to the requirements listed below, shoring plans shall include superimposed loading information as well as location and magnitude of shoring posts and towers.

B. The work of this Section shall be performed by a company which specializes in the type of shoring work required for this Project, with a minimum of 10 years of documented successful experience and shall be performed by skilled workmen thoroughly experienced in the necessary crafts.

1. Work shall be performed in compliance with Owner's insurance underwriters' requirements.

C. Testing Agency Services: Required as specified in Section 01 40 00 Quality Control, and herein.

1.05 SUBMITTALS

A. Design Calculations: The Contractor shall submit for Commissioner’s review six sets of calculations for design of the temporary shoring structures and its impact on adjacent existing structures. The calculations shall be prepared by a Licensed Structural Engineer in the state of Illinois, and meet all of the criteria stated and denoted the drawings.

B. Shop Drawings: Prior to fabrication of temporary shoring, the Contractor shall submit shop drawings for structural steel shoring fabrication and erection prepared by a qualified steel detailer (the minimum qualifications are listed in Section 05 10 30). The shop drawings shall indicate a clear and concise load path, all connections, lengths, location of field and shop splices, attachments, erection and fabrication plans, and types of steel used. The Contractor shall design all shoring according to the shoring drawing and specifications, and show details of support beams, diaphragms, jacking blocks, etc. and all necessary connections. The shop drawings shall also include the Contractor's proposed staging or procedure for execution of shoring. The Contractor

shall review all shop drawings and verify all dimensions and procedures. The Contractor shall submit shop drawings to the Commissioner for Engineer's review. Fabrication shall not commence until approval is received from the Commissioner. The Commissioner's approval of the shop drawings in no way shall relieve the Contractor of responsibility for erectability, fabrication, and fit in the field.

C. Provide a layout showing locations for shoring as required by the demolition and new construction work for this project. Indicate all field-verified dimensions and conditions included but not limited to existing structures and utilities that affect the shoring operations.

1.06 INSPECTION

A. All material and workmanship shall be subject to inspection by the Engineer in accordance with Article 105.12 Inspection of Work of the IDOT SSRBC.

PART 2 - PRODUCTS

2.01 MATERIALS

A. All materials and fabricated items shall be furnished by an established and reputable manufacturer or supplier, subject to approval by the Commissioner.

B. All structural steel used for shoring shall comply with requirements of ASTM A36/A36M. Bolts, nuts, and washers shall conform to ASTM A325.

C. Untreated timber shall be as specified in IDOT SSRBC.

D. Screenings used for leveling shall be CA-6 Gradation conforming to the requirements of Section 704 of the IDOT SSRBC.

E. Existing Shoring Towers:

1. Contractor shall reuse existing shoring towers located on site.

    a. Contractor is solely responsible for the condition of these shoring towers at the time of their use. Any deterioration shall be repaired prior to use.
    b. Contractor’s SSE shall verify that these shoring towers are adequate for the loads imposed under use.

PART 3 - EXECUTION

3.01 PREPARATION

A. The Contractor shall establish and locate all lines and levels and be responsible for correct locations of all shoring.

B. The Contractor shall verify the location of utilities or structures affected by shoring. Any disturbance or damage to existing structures or other property, caused by the Contractor's operations shall be repaired by the Contractor in a manner satisfactory to the Commissioner, at no additional cost to the City of Chicago.

C. The Contractor shall verify the support base of sufficient soil capacity for the proposed shoring.

D. Connections to existing columns shall be bolted and shall incorporate existing rivet holes if possible. Rivets shall be removed by a process which will neither damage nor weaken the column nor damage nor enlarge the existing holes.

3.02 STEEL FABRICATION

A. Structural steel shall be fabricated in accordance with Section 505, Steel Structures, of the IDOT SSRBC.

3.03 ASSEMBLY AND ERECTION

A. Structural steel shall be assembled and erected in accordance with Section 505, Steel Structures, of the Standard Specification and, also in accordance with Part 4, Erection, Chapter 15 of the AREMA Manual. Where differences occur in the provisions of the Standard Specification and the AREMA Manual, the more stringent requirement shall be followed, as determined by the Commissioner. Field welds other than those shown on the drawings are prohibited unless specifically authorized by the Commissioner.

B. Timber shall be assembled and erected in accordance with Chapter 7 of the AREMA Manual.

C. The sequence of work shall follow that outlined in the Drawings. Any deviations shall be made only with the prior approval of the Commissioner.

3.04 HYDRAULIC JACKS

A. If used, the hydraulic jacking system shall be equipped with check valves and shut-off valves to isolate individual rams. The system shall also be equipped with hydraulic pressure gauges to monitor line pressures.

B. No live loads shall be allowed to pass over the structure while it is supported by the hydraulic jacking system, unless the jack is equipped with a permanent locking mechanism that does not rely on hydrolics.

C. Jacking under live track shall be done under flag protection ONLY.

3.05 PROTECTION

A. The Contractor shall be responsible for protecting and maintaining any existing shoring of the elevated structure which is affected by his shoring operations and to prevent his own shoring from disturbance by traffic and construction.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The work of SHORING shall not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this Section. Payment for the Work of SHORING shall be included in the Contract lump sum price as shown in the Schedule for Prices for STRUCTURAL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

A. Structural Work: 030000.

END OF SECTION

SECTION 31 20 00

EARTH MOVING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. The work under this section shall include all labor, materials, tools, equipment and incidentals required as necessary. This section includes but is not limited to the following:

1. Preparing and grading subgrades.
2. Excavating and backfilling of foundations and footings, column foundations, piers, and other structures.
3. Soil and grading for planters, trees, shrubs, and landscaping.
4. Removal and disposal of unsuitable soil or subgrade materials. Removal and stockpiling of material suitable for backfilling.
5. Providing, installing and compaction of fill and backfill materials.
6. Any other earthwork as shown on the drawings or required for installation of the new or temporary work.

1.03 RELATED WORK

A. Related work specified elsewhere includes:

1. Section 024119 – Selective Demolition
2. Section 312313 – Subgrade Preparation
3. Section 312319 – Dewatering Excavations
4. Section 312323 – Granular Backfill, CA-6
5. Section 321116 – Sub-base Granular Material Type B
6. Section 321313 – Concrete Pavement

1.04 REFERENCES

A. Definitions

1. Excavation consists of removal of material encountered to subgrade elevations indicated and subsequent disposal or stockpiling materials removed.
2. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction of the Commissioner. Unauthorized excavation, as well as remedial work directed by the Commissioner, shall be at the Contractor's expense.

    a. Fill unauthorized excavation by extending indicated bottom elevation of footing or base to excavation bottom, without altering required top elevation. Lean concrete fill may be used to bring elevations to proper position, when acceptable to Commissioner. Unauthorized excavation may also be filled with compacted granular fill as approved by the Commissioner.

3. Unsuitable materials: Material which cannot be left in place for structural support of subsequent construction as determined by the Commissioner or material contaminated with fuel oil, lead, arsenic or any other regulated substances.
4. Additional Excavation: When excavation has reached required subgrade elevations, notify the Commissioner, who will make an inspection of conditions. If the Commissioner determines that bearing materials at required subgrade elevations are unsuitable, continue excavation until suitable bearing materials are encountered and replace excavated material as directed by the Commissioner.
5. Subgrade: The undisturbed earth or the compacted soil layer immediately below granular subballast, drainage fill, or topsoil materials.
6. Structure: Buildings, stations, relay houses, roadway lighting, tracks, equipment, signs, foundations, piers, footings, slabs, curbs, or other man-made stationary features occurring above or below ground surface.

1.05 QUALITY ASSURANCE

A. Codes and Standards: Perform excavation work in compliance with applicable requirements of authorities having jurisdiction.

B. Except as modified herein, the work shall be performed in accordance with the applicable portions of the IDOT SSRBC.

1. Except as modified herein, the work shall conform to the applicable portions of Section 502 of the IDOT SSRBC.
2. Excavation of unsuitable material shall conform to Section 202 of the IDOT SSRBC and Section 026100.10 of these Specifications.
3. The installation of porous granular backfill shall conform to Section 209 of the IDOT SSRBC.

C. Testing and Inspection Service: Contractor will employ and pay for a qualified independent geotechnical testing and inspection laboratory to perform soil testing and inspection service during earthwork operations as required by the Commissioner.

D. Follow all applicable regulations, codes and ordinances when removing, transporting and disposing of contaminated subgrade materials and as specified in Section 026100.10 of these Specifications.

1.06 SUBMITTALS

A. Submit each item in this Article according to the conditions of the contract and Division 01 Specification Sections, for approval, unless otherwise indicated:

B. Test Reports: As required by the Commissioner, submit the following reports directly to the Authority from the testing services, with copy to the Contractor:

1. Verification of suitability and bearing capacity of subgrade material at all foundations, in accordance with specified requirements.
2. Field reports; Including daily observations, in-place soil density tests and gradation analysis reports.
3. Test reports of unsuitable and contaminated soil or subgrade material.

C. Procedures, certificates, permits, transport and land fill manifests, etc. for removal and disposal of contaminated soil or subgrade materials.

D. Submit to the Commissioner diagrams and load data for equipment to be used on-site.

E. Test and Inspection program describing the required test to be carried out during removal, placement and compaction of soil. The program shall describe monitoring and oversight activities by the contractor's quality staff to ensure compliance with all requirements specified in contract documents and approved submittals. Advance notice of compaction efforts must be given to the Commissioner.

1.07 PROJECT CONDITIONS

A. Site Information:

1. Soil conditions are assumed to meet the design criteria implied by the details indicated on the drawings.
2. Additional test borings and other exploratory operations may be performed by Contractor, at the Contractor's option; however, no change in the Contract Sum will be authorized for such additional exploration.

B. Existing Utilities: Locate existing underground CTA, public, and private utilities, including cables, in areas of excavation work. If utilities and cable are indicated to remain in place, provide adequate means of support and protection during earthwork operations.

1. Should uncharted, or incorrectly charted, piping or other utilities be encountered during excavation, inform the Commissioner immediately. Cooperate with the Commissioner and utility companies in resolving conflicts, maintaining existing facilities, relocating existing facilities, providing access for facility relocation by others, and in keeping respective services and facilities in operation. Repair any damaged utilities to satisfaction of utility owner. Coordination by the Contractor will not be paid for separately but is included in the cost of the contract.
2. Do not interrupt existing or temporary utilities serving facilities occupied by others, except when permitted in writing by the Commissioner and then only after acceptable temporary utility services have been provided. Provide minimum of 48-hour notice to the Commissioner, and receive written notice to proceed before interrupting any utility.

C. Use of Explosives: Use of explosives is not permitted.

D. Protection of Persons and Property: Barricade open excavations occurring as part of this work and post with warning lights.

1. Operate warning lights as recommended by authorities having jurisdiction.
2. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.
3. Protect pedestrian traffic from excavations. Provide barricades and temporary concrete barriers as necessary and approved. Re-route traffic from traffic areas to be excavated.

PART 2 - PRODUCTS

2.01 SOIL MATERIALS

A. Satisfactory soil materials are defined as those complying with ASTM D2487 soil classification groups GW, GP, GM, SW, SP, and SM.

B. Unsatisfactory soil materials are defined as those complying with ASTM D2487 soil classification groups GC, SC, ML, MH, CL, CH, OL, OH, and PT. Unsuitable materials shall be classified as material which cannot be left in place for structural support of subsequent construction as determined by the Commissioner or material that is contaminated.

C. Aggregate Base Course shall be type "A" in accordance with Section 301 of the IDOT SSRBC.

D. Subbase Material: To be used under paved areas shall be naturally or artificially graded mixture of natural or crushed gravel, crushed stone, crushed slag, and natural or crushed sand, gradation CA-6 in accordance with IDOT Section 1004 of the IDOT SSRBC.

E. Backfill and Fill Materials: Satisfactory soil materials free of expansive clay, rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials,

wood, glass, metals, organic material, vegetation, concrete, bituminous pavement, masonry and other deleterious matter from on-site excavation, or CA-6 as per applicable portions of the IDOT SSRBC 2012, Section 1004. In addition, the material shall have a standard dry density of not less than 90 pounds per cubic foot when tested in accordance with AASHTO T99 and shall not possess an organic content greater than 10% when tested in accordance with AASHTO T194.

F. Granular fill or backfill shall be crushed coarse aggregate having a CA-6 gradation conforming to applicable portions of the IDOT SSRBC, Section 1004.

G. Porous granular backfill shall have a CA-18 gradation conforming to Section 1004 of the IDOT SSRBC.

H. Bedding Material: Bedding material shall be coarse aggregate having CA-11 gradation conforming to Section 1004.01 of the IDOT SSRBC. This material shall be used in all pipe trenches.

I. Drainage Fill: Washed, evenly graded mixture of crushed stone, or crushed or uncrushed gravel, ASTM D448, coarse aggregate grading size 57, with 100 percent passing a 1-1/2 inch sieve and not more than 5 percent passing a No. 8 sieve.

J. Filtering Material: Evenly graded mixture of natural or crushed gravel or crushed stone and natural sand, with 100 percent passing a 1-1/2 inch sieve and 0 to 5 percent passing a No. 50 sieve.

K. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

L. The use of chats, wet bottom boiler slag or slag sand shall not be allowed for fill.

M. Bearing soil or subbase for the installation of concrete foundation work shall be of 2500 psf bearing capacity minimum or as indicated in the geotechnical report, whichever is the greater value.

PART 3 - EXECUTION

3.01 PREPARATION

A. Protect structures, wayside equipment, stations, elevated structures, roadway lighting, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, crushing, and other hazards created by earthwork operations. Protect landscaping as necessary.

B. Protect subgrades and foundation soils against freezing temperatures or frost. Provide protective insulating materials as necessary.

C. Determine the location of any underground utilities or other items or structures that may be close to the proposed excavations. Utility lines are to be flagged before beginning the work.

D. Contractor is responsible to have the limits and elevations for their excavations properly surveyed by a licensed surveyor, and clearly marked at the site.

E. Any disturbance or damage to existing structures, utilities, or other property, caused by the Contractor's operation shall be repaired by the Contractor in a manner satisfactory to the Commissioner and at no additional cost to the Commissioner.

F. Existing pavements, alleys, curbs and sidewalks shall be saw-cut prior to removal.

G. Provide erosion control measures to prevent erosion or displacement of soils and discharge of soil bearing water runoff or airborne dust to adjacent properties.

3.02 STABILITY OF EXCAVATIONS

A. General: Comply with local codes, ordinances, and requirements of agencies having jurisdiction to maintain stable excavations.

B. Slope sides of excavations to comply with local codes, ordinances, and requirements of agencies having jurisdiction. Shore and brace where sloping is not possible because of space restrictions or stability of material excavated. Maintain sides and slopes of excavations in safe condition until completion of backfiling.

C. Shoring and Bracing: Provide materials for shoring and bracing per related work requirements specified elsewhere in contract documents, such as sheet piling, uprights, stringers, and cross braces, in good serviceable condition. Install as required to support excavation. Maintain shoring and bracing in excavations regardless of time period excavations will be open. Extend shoring and bracing as excavation progresses. Removal of any temporary earth retention structure shall coincide with placement of backfill and be performed in such a manner as to ensure stability of all adjacent structures.

3.03 DE-WATERING – REFER TO SECTION 312319 DEWATERING EXCAVATIONS

3.04 EXCAVATION

A. Excavate as necessary to the extent required per the Drawings. Remove all unsuitable materials and dispose of all materials not suited for backfill including debris, rubble, abandoned structures, existing foundations and footings, stone bases, stone piers, abandoned utility structures and pipe, pavements, curbs and gutters, tiebacks, deadmen, fill and landscaping not to be reused. All unsuitable

materials to be disposed of legally off site in accordance with Section 026100.10.

B. Excavate unsuitable soil or materials where indicated, under new structure, or as otherwise required. Excavate to solid bearing. Remove and dispose of properly all excavated unsuitable soil or other materials.

C. Excavations adjacent to existing utilities, ductbanks, roadways, equipment, structures, foundations and other objects which are to remain shall be performed in such a way as to insure the stability of the existing conditions.

D. All excavations shall be secured with temporary barriers.

E. Do not over excavate unless required to obtain solid bearing or remove unsuitable materials and only with Commissioner's approval.

3.05 EXCAVATION FOR STRUCTURES

A. Any excavation on site shall include an evaluation by a licensed structural engineer in the State of Illinois to determine adequacy of the existing track structure load transfer (vertical and lateral) into surrounding soil. In the event that formwork, shoring, or other temporary works are required, it shall be documented for submission with elevations and dimensions shown within a tolerance of plus or minus 0.10 feet, and extending a sufficient distance from footings and foundations to permit placing and removal of formwork, installation services, and other construction and for inspections.

B. Excavations for footings, piers and foundations: Do not disturb bottom of excavation, Excavate by hand to final grade just prior to placement of concrete reinforcement.

3.06 EXCAVATION FOR PAVEMENTS, WALKS AND SLABS

A. Excavate surface under slabs to comply with cross-sections, elevations and grades as indicated. Excavate as required to a solid, clean subgrade free of debris.

3.07 APPROVAL OF SUBGRADE

A. Notify the Commissioner when excavations have reached required subgrade as shown on the Contract Drawings. The prepared subgrade shall be inspected and accepted prior to the placement of foundations or slabs.

B. Shape the subgrade to a fine surface conforming to the indicated cross section, and compact the top 12 inches to a minimum 95 percent of the maximum dry density of the subgrade material as determined by ASTM D 1557. Cut down all high spots, fill depressions, and recompact until the surface is smooth and satisfactorily compacted.

C. In areas designated for grading and finishing, rake or machine-grade the areas to remove stones over two inches and other unsatisfactory material; fill depressions, and finish the surface within the indicated tolerances.

D. Compaction testing shall be in accordance with Section 205.06 of the SSRBC and submitted to the Commissioner.

E. If the subgrade fails to meet the Contract compaction requirements, the unsuitable subgrade material, the Contractor shall remove such materials to the required width and depth and replace it with Course Aggregate CA-6 according to IDOT SSRBC 1004 or as directed by the Commissioner.

F. Unsuitable soil may be soil of insufficient bearing strength or soil that is loose mixed with debris. Bearing capacity to be determined by an independent testing agent. Contractor to arrange for and pay for testing as part of the contract lump sum price.

G. Insufficient bearing soil can be corrected by deeper or wider excavation or additional excavation and compacted approved fill. Additional excavation work, compacted fill or additional concrete work required and approved by the Commissioner will be paid according to the contract provisions for changes in the work. Additional excavation must be approved in writing by the Commissioner.

H. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activity, as directed by the Commissioner.

3.08 UNAUTHORIZED, EXCESSIVE OR EXTENDED EXCAVATION

A. Fill unauthorized, excessive or extended excavation under foundations or footings by extending indicated bottom elevation of concrete foundation or footing to excavation bottom, without altering required top elevation; or fill with compacted granular fill, as approved by the Commissioner.

3.09 COLD WEATHER PROTECTION

A. Protect excavation bottoms against freezing when atmospheric temperature is less than 35 degrees F.

3.10 UNSUITABLE EXCAVATION

A. All unsuitable excavated material and excess material not used for backfill or subgrade shall be disposed of at a landfill approved by the Commissioner. The Contractor shall provide written authorization to the Commissioner for the use of that location.

3.11 GRANULAR FILL AND BACKFILL

A. Granular fill or backfill shall be placed in accordance with Article 207 of the IDOT SSRBC.

B. Granular fill CA-6 shall be used for filling unauthorized, excessive or extended excavations from the bottom of the excavation to the proposed bottom elevation. Granular fill shall be installed and compacted in layers of maximum depth of 6" per compacted layer.

C. Granular backfill CA-6 shall be used for backfilling above the bottom of footing elevation after use of all suitable backfill material.

D. Before granular backfill material is deposited under and around foundations, it shall contain the proper amount of moisture required for compaction as determined by the Commissioner for the material and compaction methods used. Moisture shall be added to the material during compaction to maintain the optimum moisture content +/- 3% as determined by ASTM D1557.

E. Granular fill or backfill CA-6 shall be placed in maximum lifts of six (6) inches and compacted immediately after placing to 95% maximum relative density as determined by ASTM D1557. The granular material shall be placed in the full width of the excavation with equipment as approved by the Commissioner and in such a manner which will not cause segregation and which will require minimum blading or manipulation.

F. Compaction tests shall be made at the direction of the Commissioner in accordance with Section 205.06 of the SSRBC.

G. Granular fill or backfill CA-6 shall be used as backfill beneath all areas of new and existing streets, asphalt, sidewalks, curbs or other pavements.

3.12 BACKFILL

A. General: Place soil material in layers to required subgrade elevations, for each area classification listed below, using materials specified in Part 2 of this Section.

1. In All Excavations: General backfill and fills, use satisfactory excavated or borrow material.
2. Under walks and pavements, use compacted granular fill only.
3. Backfill trenches with concrete where trench excavations pass within 18 inches of column or wall foundations and that are carried below bottom of such foundations or that pass under wall foundations. Place concrete to level of bottom of adjacent foundation.

B. Backfill excavations as promptly as work permits, but not until completion of the following:

1. Acceptance of construction below finish grade including, where applicable, perimeter insulation.

2. Inspection, testing, approval, and recording locations of underground utilities have been performed and recorded.
3. Removal of concrete formwork.
4. Removal of shoring and bracing, and backfilling of voids with satisfactory materials. Cut off temporary sheet piling driven below bottom of structures and remove in manner to prevent settlement of the structure of utilities, or leave in place if required.
5. Removal of trash and debris from excavation.
6. Permanent or temporary horizontal bracing is in place on horizontally supported walls.
7. Removal of temporary sheet piling and cribbing shall coincide with the placement of backfill and be performed in such a way as to insure the stability of all adjacent shoring and structures.

3.13 PLACEMENT AND COMPACTION OF BACKFILL

A. Place fill materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

B. Before compaction, moisten or aerate each layer as necessary to provide optimum moisture content. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.

C. Backfilling shall proceed immediately after concrete placement where applicable, but not prior to seven days after concrete placement or as approved by the Commissioner.

D. Place backfill and fill materials evenly adjacent to structures, piping, or conduit to required elevations. Prevent wedging action of backfill against structures or displacement of piping or conduit by carrying material uniformly around structure, piping, or conduit to approximately same elevation in each lift.

E. Control fill compaction, providing minimum percentage of density specified for each area classification indicated below. Correct improperly compacted areas or lifts as directed by the Commissioner if soil density tests indicate inadequate compaction.

1. Percentage of Maximum Density Requirements: Compact soil to not less than the following percentages of maximum density, in accordance with ASTM D1557:

    a. Under structures, track, building slabs and steps, and pavements, compact top 12 inches of subgrade and each layer of backfill or fill material at 95 percent maximum density.
    b. Under walkways, compact top 6 inches of subgrade and each layer of backfill or fill material at 95 percent maximum density.

1) Moisture Control: Where subgrade must be moisture conditioned before compaction, uniformly apply water to surface of subgrade material. Apply water to maintain optimum moisture content +/- 3%.

a) Remove and replace, or scarify and air dry, fill material that is too wet to permit compaction to specified density.

3.14 MAINTENANCE

A. Protection of Graded Areas: Protect newly graded areas from traffic and erosion. Keep free of trash and debris.

B. Repair and re-establish grades in settled, eroded, and rutted areas to specified tolerances.

C. Reconditioning Compacted Areas: Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, reshape and compact to required density prior to further construction at no additional cost to the Commissioner.

D. Settling: Where settling is measurable or observable at excavated areas after initial compaction efforts, remove surface, add backfill material, compact and replace surface. Restore appearance, quality and condition of surface or finish to match adjacent work to the satisfaction of the Commissioner.

3.15 PAVEMENT SUBBASE COURSE

A. General: Subbase course consists of placing subbase material, in layers of specified thickness, over subgrade surface to support a pavement base course. Refer to other Division 32 sections for paving specifications.

B. Grade Control: During construction, maintain lines and grades including crown and cross-slope of subbase course.

C. Shoulders: Place shoulders along edges of subbase course to prevent lateral movement. Construct shoulders of acceptable soil materials, placed in such quantity to compact to thickness of each subbase course layer. Compact and roll at least 12-inch width of shoulder simultaneous with the compaction and rolling of each layer of subbase course.

D. Placing: Place subbase course material on prepared subgrade in layers of uniform thickness, conforming to indicated cross-section and thickness. Maintain optimum moisture content for compacting subbase material during placement operations. When a compacted subbase course is indicated to be 6 inches thick or less, place material in a single layer. When indicated to be more than 6 inches thick, place material in equal layers, except no single layer more than 6 inches or less than 3 inches in thickness when compacted.

3.16 FIELD QUALITY CONTROL

A. All material, fill, and backfilling operations shall be subjected to testing at the Commissioner's discretion by a qualified testing agency retained and paid for by the Contractor and approved by the Commissioner.

B. Quality Control Testing During Construction: Allow testing service to inspect and approve each subgrade and fill layer before further backfill or construction work is performed.

1. Perform field density tests in accordance with ASTM D1557

    a. Field density tests may also be performed by the nuclear method in accordance with ASTM D2922, providing that calibration curves are periodically checked and adjusted to correlate to tests performed using ASTM D1557. In conjunction with each density calibration check, check the calibration curves furnished with the moisture gages in accordance with ASTM D6938.
    b. If field tests are performed using nuclear methods, make calibration checks of both density and moisture gages at beginning of work, on each different type of material encountered, and at intervals as directed by the Commissioner.

2. Footing Subgrade: For each strata of soil on which footings will be placed, perform at least one test to verify required design bearing capacities. Subsequent verification and approval of each footing subgrade may be based on visual comparison of each subgrade with related tested strata when acceptable to Commissioner.
3. Paved Area Subgrade: Perform at least one field density test of subgrade for every 2,000 sq. ft. of paved area of building slab, but in no case fewer than three tests. In each compacted fill layer, perform one field density test for every 2,000 sq. ft. of overlaying building slab or paved area, but in no case fewer than three tests.
4. Foundation Wall Backfill: Perform at least two field density tests at locations and elevations as directed.
5. If in opinion of Commissioner, based on testing service reports and inspection, subgrade or fills that have been placed are below specified density, perform additional compaction and testing until specified density is obtained.
6. Subgrade and Subballast: Perform a minimum of five (5) in-place field density tests per lift for every 15,000 sq. ft. but in no case fewer than three tests or as directed by the Commissioner.

3.17 DISPOSAL OF EXCESS AND WASTE MATERIALS

A. Removal from the Commissioner's Property: Remove waste and excess materials, including unacceptable or excess excavated material, trash, and debris, and dispose of it legally off Commissioner's property.

B. The Contractor shall furnish the Commissioner with information on the manner and location of disposal as well as evidence of their authority to use the location.

3.18 REMOVAL AND DISPOSAL OF UNSUITABLE MATERIAL

A. Material contaminated with fuel oil, lead or any other regulated substance must be excavated, removed and disposed of properly as hazardous waste at landfills approved by the Commissioner. All local, state, federal, OSHA, USEPA, and any other applicable regulations must be adhered to for the handling, transport, and disposal of such material. This contaminated material may be encountered during excavations, or may be otherwise identified by the Commissioner.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The work of EARTH MOVING shall not be measured for payment.

4.02 PAYMENT

A. No separate payment shall be made for the work covered in this section. Payment for the Work of EARTH MOVING shall be included in the contract lump sum price as shown in the Schedule of Prices for CIVIL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 020000.

END OF SECTION 31 20 00

SECTION 31 23 10

EXCAVATION, TRENCHING AND BACKFILLING (UTILITIES)

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This specification includes the requirements for excavation, bedding, backfilling and compaction, of utility trenches for watermain, sewer mains, gas mains, electric & telecommunication conduits and associated appurtenances.

1.03 RELATED SECTIONS

A. Section 015526 – Traffic Control.

B. Section 312000 – Earth Moving.

C. Section 312319 – Dewatering Excavations.

D. Section 330522 – Repair and Adjustment of Sewer Mains and Structures

E. Section - 331213 – Water Services

F. Section – 331214 – Water Service Termination

G. Section 333113 – Sewer Main Pipe and Fittings

H. Section – 333913 - Sewer Manholes, Catch Basins, Inlets and Special Structures

1.04 REFERENCES

A. CDOT Regulations for Openings, Construction and Repair in the Public Way (CDOT Specifications), latest edition.

B. IDOT Standard Specifications for Road and Bridge Construction (SSRBC), latest edition.

C. IDOT Supplemental Specifications and Recurring Special Provisions (SSRSP), latest edition.

D. ASTM D1557 - Laboratory Compaction Characteristics of Soil, latest edition.

E. Department of Labor, Occupational Safety and Health Administration 29 CFR Part 1926, Occupational Safety and Health Standards – Excavations; Final Rule (OSHA), latest edition.

1.05 DEFINITIONS

A. Soil types are defined as follows.

1. Trench Excavation. Excavation of soil for the purpose of installing utilities and their appurtenances, and for the restoration of surface features. The excavated material maybe classified as either clay or sandy soil, a mixture of each, and may contain varying mounts of loam, silt, gravel, organic material, or rock fragments less then one (1) cu yd in volume. Trench excavation excludes all material defined as Rock Excavation and Unsuitable Soil.
2. Rock Excavation. Excavation of naturally occurring deposits of limestone, sandstone, shale or other indigenous rock occurring as bedrock, rock ledges, outcroppings, or boulders, one (1) cu yd or larger in volume necessitating removal by the use of systematic drilling, expansive jacks, or backhoe mounted pneumatic hole punchers or rock breakers.
3. Unsuitable Soil Materials. This soil material includes varying amounts of material classified as slag, cinders, trash, debris and rubble; organic or contaminated soil and material; asphalt and concrete pavements (including aggregate sub-base); sidewalks and curbs; concrete slabs concrete or masonry foundations; metal beams, bracing, and sheet piling; or similar matter.

1.06 SUBMITTALS

Note: Any utility excavations greater than 12 feet must be submitted to the Office of Underground Communication before a building permit can be issued.

A. Submittal requirements and procedures for Shop Drawings, Product Data, Records and Samples must be submitted in accordance with Book 1 – Terms and Conditions for Construction, latest edition, issued by the City of Chicago, Department of Procurement Services.

B. Provide to the Commissioner copies of all contractual agreements, permits and / or licenses for proposed disposal sites for all material and waste removed from the job site.

C. Excavation Support Systems:

a. Prepare and submit a written schedule and procedure, along with detailed drawings, of the proposed excavations and excavation support systems.
b. Include installation procedures; method of concrete placement; excavation sequence; interface details; protection measures for

existing structures and facilities; instrumentation and monitoring procedures to check performance, sequence, and method of removal; and contingency plans for excessive wall or foundation movements.

c. The program must take into account that excavations cannot extend beyond the right-of-way into adjacent properties above or below grade, unless otherwise indicated. Where Contractor requires the installation of part of excavation protection system on private property, the Contractor will be solely responsible for securing permission from adjacent property owners to access and install such temporary and permanent systems.
   1) Any such permission from adjacent property owners must be in writing, and the owner's signature, granting such permission, must be witnessed and properly notarized. Certified copies of all such permissions must be submitted to the Commissioner for record purposes.

D. Shop Drawings: Submit Shop Drawings and specifications for support systems, lagging, and internal bracing. Include the following:

   a. Specific description of field quality control measures.
   b. Details of interface with permanent structures.
   c. Details of bracing struts and wales, if used, and the proposed installation procedures, including method and sequence of preloading.
   d. Details of required preloading systems, pre-stressing systems, load measuring facilities, systematic schedule of preloading and pre-stressing operations, and sequence of construction.
   e. Method and details for securing lagging in support system openings.
   f. Proposed method of providing for utility penetrations.
   g. Assembly and erection details of members and connections for the system.

E. Plating of Excavations: When requested submit design calculations stamped by a Structural Engineer Licensed in the State of Illinois as proof of the structural integrity of the plating provided.

F. Calculations: Submit appropriate design calculations to support Shop Drawings. Include maximum theoretical deflections of supporting members. Include calculations indicating the expected magnitude of vertical and lateral movement.

G. Professional Engineer's Certification: The excavation support systems program, Shop Drawings, calculations, and test reports must be prepared, sealed, and signed by a professional structural engineer currently registered in the State of Illinois.

H. The Contractor, before starting work, must submit to the Commissioner for approval, a layout of his construction procedures and the equipment to be used in maintaining the trees in place without damage.

I. Provide for CLSM (Flowable Fill) backfill quality control (QC) and quality assurance (QA) in accordance with the IDOT SSRSP, Check Sheet #31 "Quality Control Quality Assurance of Concrete Mixes".

PART 2 - PRODUCTS

2.01 GENERAL

A. Pipe bedding and trench backfill material must conform to the requirements and gradation specified in Section 1003, Fine Aggregates (FA), or Section 1004, Coarse Aggregates (CA), of the SSRBC.

B. Coarse Aggregate (CA) material classified, as Chert or Novaculite Gravels, or Slag from any source, are not permitted for use as bedding or backfill material.

C. Fine Aggregate (FA) material classified as Silica Sand, Slag Sand from any source, or Construction Debris Sand, are not permitted for use as bedding or backfill material.

D. All material must be dry and free of organic matter, clay, garbage, paper, wood or similar material, boulders or large particles of frozen material.

2.02 PIPE BEDDING

A. Pipe Bedding for Water Main Construction Coarse aggregate (CA) material classified as mechanically crushed gravel, mechanically crushed stone, mechanically crushed limestone, or mechanically crushed recycled concrete conforming to IDOT gradation CA-16 for water mains 16 inches in diameter or smaller, CA-11 for water mains larger then 16 inches in diameter, unless otherwise authorized by the Commissioner. Material must be washed, angular, have uniform properties, and non-corrosive. Material must have a pH range between 7.5 and 10.

B. Pipe Bedding for Sewer Main Construction Coarse aggregate (CA) material classified, as crushed gravel, crushed stone or crushed concrete must conform to gradation CA-11, unless directed otherwise by the Commissioner. Material must have a pH range between 7.5 and 10.

2.03 BACKFILL MATERIAL

A. Backfill Material for Water Main Construction

1. Coarse aggregate (CA) material classified as mechanically crushed gravel, mechanically crushed stone, mechanically crushed limestone, or mechanically crushed concrete conforming to IDOT gradation CA-16 unless authorized otherwise. Material must be washed, angular, have uniform properties, and non-corrosive. Material must have a pH range between 7.5 and 10.

B. Backfill for Sewer Construction

1. Fine aggregate (FA) material classified as sand, crushed concrete sand or stone sand must conform to gradation FA 6 unless directed otherwise by the Commissioner.

C. Controlled Low Strength Material, CLSM (Flowable Fill Material)

1. Materials for Flowable Fill must meet requirements of IDOT SSRBC Sections 593 and 1019 for Controlled Low Strength Material, CLSM.

a. Flowable fill material placed adjacent to water mains must be of a non-fly ash type mix design, mix # 2.

2.04 GEOTEXTILE FABRIC

A. Geotextile fabric must be Fabric for Silt Filter Fence and must conform to the requirements of Section 1080.02 in the SSRBC.

2.05 AGGREGATE FOR STABILIZATION OF TRENCH BOTTOMS

A. When required aggregate used to stabilize trench bottoms must have an aggregate such that the majority of the material passes a 1½ to 2½-inch sieve, with no more than 10% of the material passing the No. 16 sieve. The quality of the aggregate must meet requirements established for aggregate bedding.

PART 3 - EXECUTION

3.01 WORK AREA PREPARATION

A. Existing Work Area Condition

1. All information on subsurface exploration available to the Commissioner, if any, will be made available to the Contractor for examination. However, Commissioner in no way takes responsibility for, the interpretation, accuracy, or thoroughness of the information. It will be the responsibility of the Contractor to make such subsurface explorations as deemed necessary, to supplement information provided by the Commissioner, at no additional cost to the Commissioner.
2. Prior to excavating, thoroughly investigate the limits of the proposed trench to ascertain the existence and location of any underground structures, existing utilities or other items that might interfere with the pipe installation. Notify the Commissioner of any obstructions that will prevent the installation of the pipe or appurtenances as indicated on the Drawings. Contractor shall call DIGGER at 312-744-7000 prior to excavation activities to have all existing utilities marked in the field.

B. Clearing Work Area

1. Before starting trench excavation, all obstructions, which must be removed or relocated, must be cleared. Pavement, curbs, walks, trees, shrubs, utility poles, and other structures, which are to be preserved, must be properly braced and protected. Unless otherwise shown or directed by the Commissioner, all trees and large shrubs must be preserved with minimal damage inflicted on the root structure. When

required, small trees and shrubs may be removed and replaced with equivalent specimens if approved in advance by the Commissioner.

C. Segregation and Disposal of Soil Material

1. Surplus excavated material and excavated material unsuitable for backfilling, final grading, and landscaping, must be transported off of the Site and disposed of in disposal areas obtained by the Contractor and approved by the Commissioner.
2. Excavated material must not be stockpiled along the route of the work unless authorized beforehand by the Commissioner.

D. Pavement Removal

1. The Contractor must saw cut all concrete and asphalt pavements to their full depth prior to breaking and removing the pavement. On pavements consisting of an asphalt overlay on a concrete base, the Commissioner reserves the right to order the removal of up to 6 additional inches beyond the edge of the concrete base. This additional asphalt removal must be removed to a neat saw cut edge and will be considered incidental to the Work.
2. Utilizing drop weight equipment for the purpose of breaking the pavement is not permitted.

E. Protection or Removal of Existing Trees

1. Comply with CDOT Specifications Chapter 4, "Excavation Pavement Removal" for protection of trees, shrubs, and other improvements.
2. The Contractor is not permitted to remove trees beyond the limits of the trench excavation except as specified in these Specifications, or as shown on the Plans, or as ordered by the Commissioner.
3. The Contractor must arrange his construction operations and use the necessary equipment required, so as not to remove or damage any existing trees due to the Work to be performed under this Contract.
4. To protect the trunks of existing trees from damage, the Contractor must place 2" x 4" boards, six (6) feet long, vertically and about 6 inches apart around all trees located in the parkways along the route of the work. The boards must be held in place by wire looped around the circumference of the tree trunk. After completion of all work, the protective boards and wires must be carefully removed.
5. Any pruning of trees and roots required to permit the operation of the Contractor's equipment must be kept to a minimum, subject to the approval of the Commissioner, and must be done symmetrically by a licensed arborist. The arborist is required to obtain a permit from the City of Chicago, Bureau of Forestry, Plans and Permits Section of the Department of Streets and Sanitation, to trim and spray or in any way affect the general health or structure of trees in the public way. Prior to this approval, the Bureau will conduct an investigation at the sites of the proposed sewer. They will work with the Resident Engineer and the Contractor, and request 48-hour notice prior to starting any tree work.

F. Trench Excavations Over 12-feet Deep

1. Comply with CDOT Specifications Chapter 4, "Excavation Pavement Removal" for trenches over twelve (12) feet deep.

G. Excavating Over or Adjacent to Existing Utilities

1. The Contractor must verify the location of existing utilities in the vicinity of the work before starting construction. The Contractor is responsible for protecting, and repairing utilities damaged by the work under of this contract, at no additional cost to the City. The Contractor must coordinate all work with the owner of the utility.

H. Erosion Control

1. Install geotextile fabric under each storm inlet, catch basin and sewer manhole cover to prohibit dirt, debris and backfill material from entering the sewer system, but to permit drainage. The geotextile fabric is to be maintained until restoration is completed. After restoration is completed, remove the geotextile fabric.

I. Plating of Excavations

1. Unattended excavations in public streets, alleys, driveways, and walkways necessitated by the work must be plated, if the excavation has not been backfilled, or a temporary paved surface has been provided, or specifically authorized otherwise by the Commissioner.
2. Steel Plate(s) must be large enough to safely span the excavation with sufficient overlap beyond the edge of the excavation to provide firm support as appropriate for the type of pavement and soil encountered. Plate(s) must be firmly bedded and secured to the adjacent pavement to prevent rocking or movement, and of adequate thickness to carry anticipated loads. When plating is left in place during off-work periods, or if the Commissioner feels vehicular or pedestrian safety may be compromised, a bituminous ramp is to be provided at the perimeter of the plate(s) as appropriate to provide a smooth transition between the surface of the plate(s) and the adjacent pavement or walkway.
3. Plating subjected to vehicular traffic must be capable of carrying AASHTO H-20 traffic loading without movement or excessive deflection. The plating must be secured to the adjacent paved surface in such manner so as to prevent rocking or other movement which could expose the excavation. The name of the Contractor must be indicated on both sides of the plating.
4. When steel plates are used and left in place beyond normal working periods, a bituminous ramp must be provided at the perimeter of the plate(s), to provide a smooth transition between the surface of the plate(s) and the adjacent street pavement or walkway, unless authorized otherwise.
5. Plating of excavations is not intended as a substitution for providing traffic control, which must be provided in accordance with Section - 015526 of these specifications.

J. Protection of Existing Water Main from Contamination: Protect existing water mains from contamination by groundwater, dirt, debris, or other foreign material:

1. Prevent groundwater and surface water, dirt, debris, and other foreign material from entering the open pipe.
2. Provide water tight temporary closure of pipe before leaving work site at the end of the work day.
3. Equipment, cables, hoses, supports and all appurtenant equipment placed in the water main must be thoroughly cleaned of dirt and debris, and disinfected with chlorine solution with a chlorine concentration of at least fifty (50) parts per million.
4. Workers entering pipe must wear clean temporary disposable coveralls.
5. Install foot bath and brush and have workers entering the pipe clean footwear with chlorine solution with a chlorine concentration of at least fifty (50) parts per million.

3.02 EXCAVATION PROTECTION

A. General Requirements

1. Excavations must be protected in accordance with applicable rules, laws and regulations of Federal, State and City ordinances applicable to underpinning, shoring of excavations, and other work affecting adjoining property and the safety of worker, but must not be less than the standards and regulations established by OSHA.
2. All excavation, trenching, and sub-grade work shall require a licensed structural engineer to review and provide their seal and signature on calculations that either prove the soil as proposed for excavation and/or trenching is adequate to resist both vertical and lateral forces, or that temporary shoring and bracing systems (whether pre-engineered or site constructed) can resist both vertical and lateral forces.
3. Structural support systems are required for all excavations exceeding five (5) feet in depth. Structural support systems are to be used in all excavations in soils that are determined to be unstable or subject to cave-ins, regardless of the depth of the excavation.
4. Protective systems for any excavation exceeding ten (10) feet in depth must be designed and approved by an Structural Engineer licensed in the state if Illinois.
5. The Contractor must remove and replace, or provide the means to support any surface features when their location posses a hazard to workers in the excavation.
6. Whenever excavations cross the location of an existing underground utility, the Contractor must proceed with caution and use appropriate methods of excavation to avoid damaging the utility. The Contractor is responsible for coordinating all work with the owner of the utility.
7. Ramps, runways or ladders must be provided for ingress and egress by workers from excavations exceeding four (4) feet in depth in accordance with OSHA.
8. Surface or ground water entering excavations must be controlled by the use of appropriate equipment. If the trench interrupts the natural flow of surface water, diversion ditches or dikes must be used.

B. Protection of Adjacent Structures

1. When the stability of adjoining buildings, walls, sidewalks, pavements or other structures are endangered by the excavation operations, structural support systems such as shoring, bracing or underpinning must be used to ensure the stability of the structure.
2. The Contractor is responsible for posting and issuing all notices required to inform adjacent or adjoining property owners or other parties and such notice or notices must be served in sufficient time as not to delay the progress of the Work under this Contract.
3. Excavation requires either of the following:

    a. A Structural Engineer or Professional Engineer licensed in the state of Illinois has determined that the structure is located far enough away from the excavation so as to be unaffected, or
    b. A Structural Engineer licensed in the state of Illinois has designed and approved a structural support system to provide adequate protection to the existing structure.

C. Structural Support Systems Structural support systems may consist of pre-engineered systems such as aluminum hydraulic shoring, trench shields, trench boxes, or systems constructed on the job site such as timber or steel shoring or steel sheet piling.

1. Pre-Engineered System

    a. Pre-engineered structural support systems installed in accordance with the manufacturer's recommendations do not require certification by a Structural Engineer when trench depth is less than twenty (20) feet. However, the Commissioner, at his sole discretion, may require a manufacturer's certification indicating the support system is suitable for the intended use and site conditions.
    b. Pre-engineered structural support systems will require analysis and certification by a Structural Engineer licensed in the state of Illinois, when trench depth exceeds twenty (20) feet.

2. Site Constructed Systems

    a. Construct steel sheet piling system in accordance with Division 05 of these Specifications.
    b. Structural support systems built in place and made of timber constructed in accordance with OSHA Standards, do not require certification by a Structural Engineer licensed in the state of Illinois, provided trench depths shown in the OSHA Standard, relative to the soil type at the site, are not exceeded.
    c. If the OSHA Standard is not followed for timber shoring and the depths of trenches exceed those in the tabulated data; or soil conditions have been determined to be substantially different that those given in the OSHA Standard; the design must be performed and certified by a Structural Engineer licensed in the state of Illinois.
    d. A structural support system built in place and consisting of materials other than a timber shoring systems will require design and certification by a Structural Engineer licensed in the state of Illinois.
    e. When close-sheeting is used, it must be driven so as to prevent adjacent soil from entering the trench either below or through such

sheeting. Tight-sheeting must be used in that portion of the excavation in or along streets or alleys below the intersection of a 1 to 1 slope line from the nearest face of the excavation to the edge of the pavement.

f. Sheeting must not be in contact with existing pavement but must bear uniformly against the sides of the excavation.

3. Where structural support systems, such as steel or wood sheeting are used for stabilizing excavations, the width of the trench may be increased as necessary to accommodate installation of the work. When soils in the lower limits of the excavation have been determined to have adequate stability; the Contractor may end the shoring elements above the bottom of the excavation. If soil begins moving into the excavation below the shoring during construction, the Contractor is solely responsible for making corrections to the excavation and for lowering the shoring, at his own expense.
4. When structural support systems are required to be left in place, they must be cut off at the same elevation as the bottom of the water main, unless otherwise directed by the Commissioner. Bracing that is to remain in place must be driven up tight. The right of the Commissioner to request sheeting and bracing to be left in place, is not meant to construe any liability or obligation on behalf of the Commissioner to issue such orders.
5. Structural support systems that are not to be left in place may be removed only when the excavation has been backfilled to such an elevation so as to prevent the collapse of the sides of the excavation. Any voids created by the removal of the structural support system members, must be filled and compacted in an acceptable manner.

3.03 EXCAVATION

A. Trench Excavation (Open Cut)

1. The width of the trenches must provide adequate space for workers to place and join the pipe properly, and must be kept to the minimum practical width. Unless otherwise approved by the Commissioner, the total clear width of the trench at the level of the top of the pipe and at grade must be at the Neat Lines as detailed on the Drawings.
2. The Contractor must excavate a minimum of 6-inches below the bottom of the pipe unless otherwise shown, specified, or directed, so bedding material can be placed in the bottom of the trench and shaped to provide a continuous firm bearing for the pipe barrel. Bell holes must be provided for proper make-up of the joints.
3. The open excavated trench preceding the pipe laying operation and the unfilled trench with pipe in place must be kept to a minimum length causing the least disturbance. The maximum length of open trench must not exceed 300-feet unless otherwise directed by the Commissioner. Comply with Article 4G, CDOT Specifications, for other trench opening length requirements within the public right-of-way.
4. Excavation In Arterial Streets. Comply with Article 4C, CDOT Specifications, for protection requirements when working within arterial streets.

5. Contractor must saw cut existing pavement prior to excavating. Width of saw cut pavement must be such that any sheeting provided for excavation protection is not in contact with the pavement.
6. Where water is encountered in the excavation, the excavation must be dewatered in accordance with Section 312319 – Dewatering Excavation of these specifications.

B. Rock Excavation (open cut)

1. Whenever rock, stone, masonry or other hard, unyielding material is encountered at or above the required trench bottom elevation, remove it to provide a clearance of no less that 8-inches below and on each side of pipes and associated fittings, valves and other appurtenances. Backfill the over excavated area with granular bedding material.
2. Removal of Rock by blasting or by use of a drop hammer is not permitted under this contract.
3. Excavate rock as near as practicable to the outside shape of the work as shown on the Plans. Solid rock, not loosened from the adjacent solid rock, may extend within the neat outside surfaces of these shapes no more than two (2) inches, provided no single projection exceeds one and one-half (1.5) square feet in area at the neat surfaces of the excavation and provided that on any ten (10) foot section of the excavation the total area of such projection at the neat outside surfaces of the section does not exceed twenty (20) percent of the area of the section.
4. The Contractor is required to remove all loose rock and other material from the excavation and in the event that the excavation is enlarged beyond the outside shape of the sewer or sewer structures as shown on the Plans, the Contractor will not be entitled to any payment for the additional Class SI concrete needed to fill the voids caused by such over-breakage.
5. Where rock is encountered, excavate to eight (8) inches below the bottom of the pipe for bedding placement.

C. Trench Excavation (Short Tunnel Construction)

1. In some instances, trees, fire hydrants, sidewalks, and other obstructions may be encountered, the proximity of which may be a hindrance to open cut excavation. In such cases, the Contractor must excavate by means of short tunnels in order to protect such obstructions against damage. Short tunnel work will be considered incidental to the construction and no additional payment will be allowed.

D. Additional Trench Excavation

1. If the soils encountered at the elevations specified are not suitable, or it is determined necessary to go to an additional width and depth, or required to fill designated areas for work done under Section 026100.10 the excavation must be carried to such additional width and/or depth and must fill such excavated areas with approved backfill material as required or directed by the Commissioner.

E. Unauthorized Excavation

1. Wherever the excavation is carried beyond or below the lines and grades shown on the Drawings all such excavated space must be refilled with select fill materials and in such manner as may be directed in order to insure the stability of all affected structures. Beneath all structures, space excavated without authority must be refilled by the Contractor with approved backfill materials and will be considered incidental to the construction and no additional payment will be allowed.

F. Trenching Across or Over Existing Excavations or Utility Trenches

1. In the event that the trench passes over or through a previous excavation, carefully compact and stabilize the bottom of the new trench or excavation to a density equal to or greater than 95% of the maximum dry density as determined by ASTM D1557. Perform this compaction carefully to avoid damaging the existing utility or structure.

G. Special Excavation

1. Remove unsuitable materials to provide two (2) feet minimum horizontal and vertical clearance around water mains or related structures as applicable, unless otherwise directed by the Commissioner.

H. Excavation in Tunnel

1. The tunnel must be excavated and trimmed to such size and shape as will allow the placing of the full section of the pipe as shown on the Plans after all lining is in place.
2. The Contractor must excavate the tunnel and support the surrounding earth so there is no movement of the earth over or adjacent to the work at any time. The Contractor must excavate the tunnel and support the surrounding earth so at no time there is more than 5 feet, measured horizontally, unsupported by bracing as approved by the Commissioner.
3. The Contractor must use extreme care in excavating and trimming to insure that a full section will be placed without materially deviating from the correct lines and grades of the finished structure.
4. In case, due to bad soil conditions, the Contractor requests that the outside outline of the sewer be changed to a minor extent to accommodate his method of construction, such a change will be allowed provided the strength of the structure is not impaired. Any such modification will not alter the price per foot specified to be paid for the completed sewer, whether such minor modification results in a minor addition or subtraction from the theoretical quantity for the section herein specified.
5. If permission is given the Contractor to excavate the tunnel for a specified distance without immediately placing the concrete lining, the proposed method of bracing the tunnel and the extra bracing necessary must be submitted for approval.
6. No additional payment or allowance of any nature will be made for timber cants, steel plates or other forms of tunnel lining used for supporting the earth during construction. All such tunnel lining must be left in place.

3.04 PLACEMENT OF PIPE BEDDING

A. Pipe Bedding

1. Pipe laid in trenches must be bedded in accordance with the details shown on the Drawings. Bedding material must consist of compacted; well-graded crushed stone fill material as shown and as specified, or as directed by the Commissioner.
2. Existing underground structures, tunnels, conduits, and pipes crossing the excavation must be bedded with compacted sand. Bedding material must be placed under and around each existing underground structure, tunnel, conduit, or pipe as required to stabilize the excavation.
3. At each joint, enough depth and width must be provided around the pipe so that joints can be properly made up.

B. Bedding Placement – Vaults and Structures

1. Pipe bedding beneath precast bases, cast-in-place bases and other foundations must be 6-Inches in thickness and thoroughly compacted in place to not less than 95% of the maximum dry density as determined by ASTM D1557.

C. Bedding and Backfill for Short Tunnel

1. Pipes placed in short tunnels must be bedded in sand. The annular space between the pipe and undisturbed earth must be completely filled with compacted sand fill material. Pipelines in short tunnels must be supported to permit the placement of backfill.

3.05 BACKFILLING EXCAVATIONS

A. General

1. All excavations must be backfilled to the original surface of the ground or to such other grades shown on the Drawings or as directed by the Commissioner. For areas to be covered by topsoil, backfill must be left 6-inches below the finished grade or as shown on the Drawings, or directed by the Commissioner. All backfilling must be done as soon as possible after the utility has been installed and inspected, and as soon as mortar for masonry or thrust blocks have sufficiently set, unless directed otherwise by the Commissioner.
2. Crushed stone fill material must be used for trench and structure backfill and other areas as shown, specified, or ordered by the Commissioner.
3. Unsuitable material and material rejected by the Commissioner must immediately be removed from the Site and disposed of by the Contractor at his expense.
4. Construction equipment used to backfill against and over cast-in-place concrete structures must not be permitted to travel over these structures until the designated concrete strength has been obtained, as verified by concrete test cylinders. In special cases where conditions warrant, as determined by the Commissioner, the above restriction may be modified if the concrete has gained sufficient strength, as determined from test

cylinders, to satisfy design requirements for the removal of forms and the application of load.

B. Backfill Procedure

1. Crushed stone fill material must be used for backfill where roadways, driveways, sidewalks or other pavements are to be placed on the backfill or where the edge of the trench excavation is 5 feet or less from any county or state highway, any city or village street pavement and in any trenches crossing pavements or sidewalks from a distance beyond the edge of the pavement or sidewalk equal to the depth of the trench. Crushed stone fill material must be used as backfill in trenches parallel to roadways, driveways or other pavements from the top of the bedding to a depth below the ground surface equal to the distance between the inner face of the trench and the closest edge of the pavement.
2. Where pavements and appurtenances for streets are to be placed over the trenches, the backfill material must be placed in uniform layers not greater than 6-inches in thickness and compacted in place. Each layer must be compacted to or not less than 95% of the maximum dry density as determined by ASTM D1557.
3. All pipe sewers must be surrounded and covered by trench backfill above the granular embedment as soon as they are laid. The trench backfill must be properly compacted and tamped to a depth of at least one foot above the top of the pipe prior to placing the remainder of backfilling.
4. For sewer pipe construction with FA 6 backfill, water jet the backfill to the depth of approximately two-thirds of the depth of cover over the sewer. The distance between jetting holes must not exceed 10 foot along the length and width of the trench, or as directed by the Commissioner. Water jetting of the trench backfill must proceed as soon as practicably, as determined by the Commissioner. The Contractor, in this manner, must place and compact the trench backfill to the level of the sub-grade.
5. Excavated material can be re-used as backfill only if directed or approved by the Commissioner.
6. Trench backfilling work must be done in such a way so as to prevent damage to any pipe, utility, or structure.
7. On monolithic concrete sewers and structures cast-in-place, trench backfill must not be placed until the concrete has attained a compressive strength of 2,000 psi.

C. Backfill under a Supported Water Main

1. Backfill the open trench under the water main and 10 feet beyond the water main sides with approved material up to a level of 1-foot below the invert of the supported water main. The backfill material must be placed in layers of 12-Inches with each layer mechanically compacted to 95% of the maximum dry density as determined by ASTM D1557.
2. Place pipe bedding material from 1-foot below the water main invert to the water main centerline and compact to achieve 95% of the maximum dry density as determined by ASTM D1557.
3. Remove the water main pipe support systems, supporting beams, and pipe support straps; and cut-off and remove soldier piles to a level at least four (4) feet below finished grade.

4. The water main pipe must be inspected for leakage and joint integrity and repaired if necessary, prior to backfilling above the water main.
5. After approval by the Engineer, continue backfilling with approved material. The open trench must be backfilled up to the required sub grade level. The backfill material must be placed in layers of 12-Inches with each layer mechanically compacted to 95% of the maximum dry density as determined by ASTM D1557.

D. Backfilling with Controlled Low Strength Material (CLSM) - Flowable Fill

1. Do not place the mix on frozen ground, in standing water, or during wet weather conditions. Mixing and placing may begin only if the air temperature is 35 °Farenheit minimum and rising. At time of placement, the material temperature must be 40 °Farenheit minimum. Mixing and placing must stop when the air temperature is 40 °Fahrenheit and falling or when the anticipated air temperature will be 35 degrees F or less in the 24-hour period following proposed placement.
2. Place the mix directly from the chute into the space to be filled. Other placement methods may be approved by the Commissioner if the mix design is appropriate.
3. When backfilling against structures, place the mix in layers to prevent damage by lateral pressures. Side slopes must be stepped or serrated to prevent wedging action of the backfill against the structure. Allow each layer to harden prior to placing the next layer.
4. When backfilling pipe trench, distribute the mix evenly on each side of the pipeline to prevent movement.
5. The mix must not be exposed to freezing temperatures or wet weather conditions during the first twenty (24) hours after placement.
6. The mix may be subjected to loading upon approval by the Commissioner, or when a penetration of 39 mm / blow or less has been obtained with the Dynamic Cone Penetrometer test.
7. Backfilling against water main pipe with CLSM is not allowed, unless authorized otherwise by the Commissioner. Contractor must provide a minimum of 6-inches of coarse aggregate backfill material over the water main pipe prior to placing the CLSM material.

3.06 FINISH GRADING

A. Finish grading must be performed in accordance with the completed contour elevations and grades shown and must be made to conform to the existing ground surface. All finished graded surfaces must be left smooth and firm and graded to permit positive drainage.

3.07 TRAFFIC CONTROL

A. The Contractor is responsible for traffic control and the protection of vehicular and pedestrian traffic from the work. For detailed requirements see Section 015526.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The work of EXCAVATION, TRENCHING, & BACKFILLING (UTILITIES) shall not be measured for payment.

4.02 PAYMENT

A. No separate payment shall be made for the work covered in this section. Payment for the Work of EXCAVATION, TRENCHING, & BACKFILLING (UTILITIES) shall be included in the contract lump sum price as shown in the Schedule of Prices for CIVIL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 020000.

END OF SECTION 31 23 10

SECTION 31 23 13

SUBGRADE PREPARATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section specifies requirements for subgrade preparation. The work under this Section will include furnishing all labor, materials, tools, and equipment required for the preparation of subgrade under roadway pavements, sidewalks and curb and gutters.

B. Except as modified herein, the work must conform to the applicable portions of the Standard Specifications, Sections 212, 301, and 606.

C. Related Sections: Related work specified, measured, and paid for elsewhere includes:

1. Section 312000: Earth Moving
2. Section 321116: Sub-Base Granular Material, Type B
3. Section 321621: Concrete Curbs, Gutters and Walks
4. Section 321623: Portland Cement Concrete Sidewalk, 5-Inch
5. Section 321623.10: Portland Cement Concrete Sidewalk, Special

1.03 REFERENCES

A. Illinois Department of Transportation (IDOT) Standard Specifications for Road and Bridge Construction, Adopted April 1, 2016 or latest edition.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01 SUBGRADE PREPARATION

A. Conform to IDOT Standard Specifications for Road and Bridge Construction.

B. Refer to Section 312000 – Earth Moving

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The Work of SUBGRADE PREPARATION will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the Work of SUBGRADE PREPARATION will be included in the contract lump sum price as shown in the Schedule of Prices for CIVIL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 020000.

END OF SECTION 31 23 13

SECTION 31 23 19

DEWATERING EXCAVATIONS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This section includes requirements for dewatering excavations when necessary to provide a safe working environment and protect the Work so as to provide a satisfactory installation.

1.03 SUBMITTALS

A. Refer to Book 1 for submittal requirements and procedures for Shop Drawings, Product Data, Records and Samples.

B. Prior to commencing excavation work at the project site, the Contractor must submit to the Commissioner for review and comment a method for removing water which has entered the excavation either from groundwater sources, surface drainage, or other source such as the dewatering of a new or existing water or sewer main. The submittal must include a description of the source of the water, equipment to be used to dewater the excavation, the arrangement of the equipment, time needed to dewater the excavation, method of disposal, and discharge rate of the equipment expressed in gallons per minute. No excavation is to be started until authorization has been given by the Commissioner to proceed with the excavation work.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.01 PREPARATION

A. Capacity of Facilities

1. Facilities for the removal and disposal of water must be of sufficient capacity to keep the excavation dry under all circumstances.

B. Standby Facilities

1. Adequate standby facilities must be provided to insure that the excavation will be kept dry in the event of power failure or mechanical breakdown.

C. Well Points

1. If well points are used, the Contractor must make provisions for removing and resetting individual well points without taking any part of the dewatering system out of service.

3.02 CONSTRUCTION

A. Dewatering

1. At all times during the excavation period and until completion of the Work and acceptance at final inspection, ample means and equipment must be provided with which to promptly remove and properly dispose of all water entering any excavation including leakage from the existing water main which is to be replaced. All excavations associated with the Work must be kept dry. Water must not be allowed to rise over, or to come in contact with, masonry and concrete until the concrete and mortar has attained a set satisfactory to the Commissioner and, in any event, no sooner than twelve (12) hours after placing the masonry or concrete.

B. Groundwater Levels

1. The Contractor must maintain the groundwater level at least 12-inches below the bottom of the excavation until the work has been completed and the excavation has been backfilled.

C. Water Management

1. Water pumped or drained from the Work must be disposed of in a suitable manner without damage to adjacent property, other Work under construction, street pavement, and parks. Water must not be discharged onto streets without adequate protection at the point of discharge. No water containing settleable solids may be discharged into sewers.
2. All damages caused by dewatering the Work must be the responsibility of the Contractor and must be promptly repaired at the Contractor's expense.
3. Limit dewatering flow rates to current operating capacity of City sewers.

D. Pumping, Bailing and Diversion

1. The Contractor must at all times during construction provide and maintain ample means and devices for the temporary diversion of flow in existing sewers and drains and the prompt removal and proper disposal of all water or sewage entering the tunnels, trenches or other parts of the work, and must keep said excavations as dry as practicable until the structures to be built therein is completed. All water pumped or drained from the work and from

existing sewers must be disposed of in a suitable manner without damage to adjacent property, or to sewers, pavements, electrical conduits or other work or property. The Contractor must provide all temporary flumes or pipe lines and pumping equipment required for the proper diversion of sewage and removal of drainage from the work.

2. Whenever the Contractor removes an existing bulkhead, he must install a screen suitable for the purpose of preventing construction debris from floating into the completed portions of the sewer system. As work progresses, Contractor must clean the completed portions of the sewer by removing rails, jacks, lumber, sandbags and all other construction equipment, excess material and debris.
3. The Contractor must place and maintain all temporary dams, flumes, bulkheads or other structures necessary to prevent water from adjacent sections of the sewer system from entering the work under this Contract in such a manner as to injure it, and must completely remove all such temporary structures from the completed portion of the work as rapidly as practicable. The Contractor must not place a dam, flume or bulkhead in any sewer without first obtaining the approval of the Commissioner. The Contractor must ascertain the possibility of sewage backing up into basements and causing damage and he will be held responsible for any such damage.
4. The City does not assume responsibility for providing the Contractor with an outlet for any storm water or sewage which must be disposed of during the construction work under this Contract. Until the acceptance of the work, the Contractor will, if so ordered by the Commissioner, keep the entire work pumped free of water and sewage and before the acceptance of any part of the work. Contractor must clean the entire length of such finished part of the work to the satisfaction of the Commissioner.
5. Water must not be allowed to flow over or stand on the pipe or structure invert in such a manner as to cause scouring of the surface.
6. Route all water pumped from trenches or other excavations to settling basins (five feet by ten feet by two feet deep with three compartments) before entering the City of Chicago sewer system. Discharge from the settling basin must be by gravity to the catch basin.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The work of DEWATERING EXCAVATIONS shall not be measured for payment.

4.02 PAYMENT

A. No separate payment shall be made for the work covered in this section. Payment for the Work of DEWATERING EXCAVATIONS shall be included in the contract lump sum price as shown in the Schedule of Prices for CIVIL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 020000.

END OF SECTION 31 23 19

SECTION 31 23 23

GRANULAR BACKFILL, CA-6

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section specifies requirements for GRANULAR BACKFILL CA-6. The work under this Section will include furnishing all labor, materials, tools, and equipment required for the installation and compaction of GRANULAR BACKFILL CA-6.

B. Related Sections:

1. Section 312000: Earth Moving
2. Section 312310: Excavation, Trenching and Backfilling (Utilities)
3. Section 315000: Excavation Support and Protection
4. Section 316400 Caissons/Drilled Piers

1.03 REFERENCES

A. Except as modified herein, the work must conform to the applicable requirements of Section 1004 of the Illinois Department of Transportation (IDOT) Standard Specifications for Road and Bridge Construction, Adopted April 1, 2016, or latest edition.

1.04 SUBMITTALS

A. Submit a representative sample of the CA-6 aggregate to the Commissioner for approval.

PART 2 - PRODUCTS

2.01 GENERAL

A. The material must be crushed coarse aggregate having a CA-6 gradation and conforming to the applicable portions of Section 1004 of the Standard IDOT Specifications.

B. The use of slag or similar metal bearing rocks will not be permitted.

PART 3 - EXECUTION

3.01 GRANULAR BACKFILL CA-6

A. GRANULAR BACKFILL CA-6 must be uniform in gradation. Before the material is deposited at foundations, it must contain the amount of moisture required for compaction. The amount of moisture required will be determined by the Commissioner for the material and compaction methods being used. Moisture must be added to the material during compaction only when it is necessary to increase the percentage of moisture to obtain satisfactory compaction.

B. GRANULAR BACKFILL CA-6 must be placed in maximum lifts of six (6) inches and compacted immediately after placing to 98% maximum relative density as determined by AASHTO T99, Method C. The granular material must be placed in the full width of the excavation with equipment as approved by the Commissioner and in such a manner which must not cause segregation, which will require minimum blading or manipulation and which will cause no damage to adjacent or underlying structures.

3.02 TESTING

A. Testing of material is the responsibility of the contractor. The Commissioner has the option to test materials if so desired. The contractor shall use an AASHTO accredited lab for all testing.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

The Work of GRANULAR BACKFILL, CA-6 will not be measured for payment.

4.02 PAYMENT

No separate payment will be made for the work covered in this section. Payment for the Work of GRANULAR BACKFILL, CA-6 will be included in the contract lump sum price as shown in the Schedule of Prices for CIVIL WORK for all applicable work performed with the CIVIL WORK pay item account and STRUCTURAL WORK for all applicable work performed with the STRUCTURAL WORK pay item account.

4.03 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 020000

B. Structural Work: 030000

END OF SECTION 31 23 23

SECTION 31 23 24

CU STRUCTURAL SOIL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes CU Structural Soil work as shown and specified.

1.3 SUBMITTAL

A. Product Data: Submit data demonstrating compliance with specifications.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Do not deliver or place soils in frozen, wet, or muddy conditions. Material shall be delivered at or near optimum compaction moisture content as determined by AASHTO T 99 (ASTM D 698). Do not deliver or place materials in an excessively moist condition (beyond 2 percent above optimum compaction moisture content as determined by AASHTO T 99 (ASTM D 698).

B. Protect soils and mixes from absorbing excess water and from erosion at all times. Do not store materials unprotected from large rainfall events. Do not allow excess water to enter site prior to compaction. If water is introduced into the material after grading, allow material to drain or aerate to optimum compaction moisture content.

1.5 EXAMINATION OF CONDITIONS

A. Inspect all areas to receive CU Soil before starting work and report all defects such as incorrect grading, compaction and inadequate drainage, etc., to the Architect prior to beginning this work.

B. The Installer is responsible for judging the full extent of work requirements involved, including but not limited to the potential need for temporary storage and staging of soils, including moving soil stock piles at the site to accommodate scheduling of other work and the need to protect installed soils from compaction, erosion and contamination.

1.6 QUALITY ASSURANCE

A. Qualifications of Installer: The work of this Section shall be performed by a Landscape Contracting firm which has a minimum of 5 years' experience successfully installing

planting mixes of a similar quality, schedule requirement and construction detailing to this project.

B. Water: Furnish water to the site at no extra cost. It is the Contractor's responsibility to correct all work injured or damaged due to the lack of water, or the use of too much water. Use water which is free from impurities injurious to vegetation.

PART 2 - PRODUCTS

2.1 CU SOIL

A. A uniformly blended mixture of Quartzite Crushed Stone, Clay, Loam and Hydrogel, as prepared by Midwest Trading Horticultural Supplies, Inc., P.O. Box 1005, St. Charles, Illinois 60174 P: (847) 742-1840 or other company licensed by Cornell University.

PART 3 - EXECUTION

3.1 UNDERGROUND UTILITIES AND SUBSURFACE CONDITIONS

A. Notify the Architect of any subsurface conditions, which will affect the Installer's ability to complete the work.

B. Verify location of all underground utilities with appropriate sources prior to construction. Contact DIGGER. at least 48 hours before commencing with construction operations. Repair damaged utilities.

C. Remove rock or other underground obstructions and drain areas to receive CU Soil only when approved by the Architect. Payment of extra shall be based on in-place volume.

D. Call conflicts with utilities to the Architect's attention before proceeding with work. Alternate locations may be designated by the Architect

3.2 SITE PREPARATION

A. Do not proceed with the installation of the CU Soil material until all walls, curb footings and utility work in the area have been installed. For site elements dependent on CU Soil for foundation support, postpone installation until immediately after the installation of CU Soil.

B. Excavate and compact the proposed sub-grade to depths, slopes and widths as shown on the Drawings. Maintain all required angles of repose of the adjacent materials as shown on the drawings. Do not over excavate compacted sub-grades of adjacent pavement or structures.

C. Confirm that the sub-grade is at the proper elevation and compacted as required. Sub-grade elevation shall slope parallel to the finished grade and or toward the subsurface drain lines as shown on the drawings.

D. Clear the excavation of all construction debris, trash, rubble and any foreign material. In the event that fuels, oils, concrete washout silts or other material harmful to plants

have been spilled into the sub-grade material, excavate the soil sufficiently to remove the harmful material. Fill any over excavation with approved fill and compact to the required sub grade compaction.

E. Do not proceed with the installation of CU Soil until all utility work in the area has been installed. All subsurface drainage systems shall be operational prior to installation of CU Soils.

F. Protect adjacent walls, walks and utilities from damage or staining by the soil. Use 1/2" plywood and or plastic sheeting as directed to cover existing concrete, metal and masonry work and other items as directed during the progress of the work.

1. Clean up all trash and any soil or dirt spilled on any paved surface at the end of each day
2. Any damage to the paving work caused by the soils installation shall be repaired by the general Contractor at the CU Soils installer's expense.
3. Maintain all silt and sediment control devices required by applicable regulations. Provide adequate methods to assure that trucks and other equipment do not track soil from the site onto adjacent property and the public right of way.

3.3 INSTALLATION OF CU SOIL MATERIAL

A. Install CU Soil in 6-inch lifts and compact each lift.

B. Compact all materials to peak dry density from a standard AASHTO compaction curve (AASHTO T 99) not less than 95% Proctor density. No compaction shall occur when moisture content exceeds maximum as listed herein. Delay compaction 24 hours if moisture content exceeds maximum allowable and protect CU Soil during delays in compaction with plastic or plywood.

C. Bring CU Soils to finished grades as shown on the Drawings. Immediately protect the CU Soil material from contamination by toxic materials, trash, debris, water containing cement, clay, silt or materials that will alter the particle size distribution of the mix with plastic or plywood.

3.4 FINE GRADING

A. Adjust the finish grades to meet field conditions as directed.

1. Provide smooth transitions between slopes of different gradients and direction.
2. Fill all dips and remove any bumps in the overall plane of the slope.
3. The tolerance for dips and bumps in CU Soil areas shall be a 3" deviation from the plane in 10'.

3.5 FINE GRADING

A. Upon completion of the CU Soil installation operations, clean areas within the contract limits. Remove all excess fills, soils and mix stockpiles and legally dispose of all waste materials, trash and debris in accordance with State and local requirements. Remove all tools and equipment and provide a clean, clear site. Sweep, do not wash, all paving

and other exposed surfaces of dirt and mud until the paving has been installed over the CU Soil material. Do not wash until finished material covering CU Soil material are in place.

PART 4 - EXECUTION

4.1 MEASUREMENT AND PAYMENT

A. The work of CU STRUCTURAL SOIL shall not be measured for payment.

4.2 PAYMENT

A. No separate payment shall be made for the work covered in this section. Payment for the Work of CU STRUCTURAL SOIL shall be included in the contract lump sum price as shown in the Schedule of Prices for CIVIL WORK.

4.3 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 020000

END OF SECTION 31 23 23

SECTION 31 50 00

EXCAVATION SUPPORT AND PROTECTION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions, apply to this Section.

1.02 SUMMARY

A. This Section includes temporary excavation support and protection systems.

B. Related Sections include the following:

1. Division 1 Section "Temporary Facilities and Controls" for temporary utilities and support facilities.
2. Section 31 20 00 - Earthwork Moving
3. Section 31 23 10 – Excavation, Trenching and Backfilling (Utilities)
4. Section 02 16 10 - Geotechnical and Structural Monitoring Instrumentation

1.03 SUBMITTALS

A. OUC Submittals for excavations greater than 12-feet deep as required by the Office of Underground Coordination.

B. Shop Drawings: Prepared by or under the supervision of a qualified structural engineer for excavation support and protection systems.

1. Shop Drawings shall be signed and sealed by a State of Illinois Licensed Structural Engineer responsible for their preparation.

C. Qualification Data: For Installer and professional engineer.

D. Photographs or videotape, sufficiently detailed, of existing conditions of adjoining construction and site improvements that might be misconstrued as damage caused by the absence of, the installation of, or the performance of excavation support and protection systems.

E. Loads Imposed Drawings: Any temporary support or protection that changes the anticipated loading condition on a structure or utility shall be submitted. Submittal

shall including a clear and concise diagram of the change in load and anticipated load path.

1.04 PERFORMANCE REQUIREMENTS

A. Design, furnish, install, monitor, and maintain excavation support and protection system capable of supporting excavation sidewalls and of resisting soil and hydrostatic pressure and superimposed and construction loads.

B. Provide structural engineering needed to assume engineering responsibility, including preparation of Shop Drawings and a comprehensive engineering analysis by a State of Illinois Licensed Structural Engineer.

C. Prevent surface water from entering excavations by grading, dikes, or other means.

D. Install excavation support and protection systems without damaging existing buildings, pavements, utilities and other improvements adjacent to excavation.

1.05 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by the Authority or others unless permitted in writing by the Commissioner and then only after arranging to provide temporary utility services according to requirements indicated.

B. Project-Site Information:

1. A geotechnical report has been prepared for the track and renewal and passenger station portion of this project and is part of the Contract Documents.
2. Make additional test borings and conduct other exploratory operations necessary for excavation support and protection.
3. The geotechnical report is referenced in the General Notes per Drawing S-001.

C. Survey adjacent structures and improvements, employing a qualified professional engineer or land surveyor; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.

1. During installation of excavation support and protection systems, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations and positions for comparison with original elevations and positions. Promptly notify the Commissioner if changes in elevations or positions occur or if cracks, sags, or other damage is evident in adjacent construction.

PART 2 - PRODUCTS

2.01 MATERIALS

A. General: Provide materials that are either new or in serviceable condition.

B. Structural Steel: ASTM A 36/A 36M, ASTM A 690/A 690M, or ASTM A 992/A 992M.

C. Cast-in-Place Concrete: ACI 301, of compressive strength required for application.

D. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.

E. Steel Sheet Piling: ASTM SPEC – Weld Metal Lagging

F. Timber: Structural No. 1 Grade or Better

PART 3 - EXECUTION

3.01 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards that could develop during excavation support and protection system operations.

1. Shore, support, and protect utilities encountered.

B. Install excavation support and protection systems to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from the Commissioner and/or other agencies and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

C. Locate excavation support and protection systems clear of permanent construction so that forming and finishing of concrete surfaces is not impeded.

D. Monitor excavation support and protection systems daily during excavation progress and for as long as excavation remains open. Promptly correct bulges, breakage, or other evidence of movement to ensure that excavation support and protection systems remain stable.

E. Promptly repair damages to adjacent facilities caused by installing excavation support and protection systems.

3.02 SOLDIER BEAMS AND LAGGING

A. Install steel soldier beams before starting excavation. Space soldier beams at regular intervals not to exceed allowable flexural strength of wood lagging. Accurately align exposed faces of flanges to vary not more than 2 inches from a horizontal line and not more than 1:120 out of vertical alignment.

B. Install wood lagging within flanges of soldier beams as excavation proceeds.

C. Trim excavation as required to install lagging. Fill voids behind lagging with soil, and compact.

D. Install wales horizontally at centers indicated and secure to soldier beams.

3.03 SHEET PILING

A. Before starting excavation, install one-piece sheet piling lengths and tightly interlock to form a continuous barrier. Limit vertical offset of adjacent sheet piling to 60 inches. Accurately align exposed faces of sheet piling to vary not more than 2 inches from a horizontal line and not more than 1:120 out of vertical alignment. Cut tops of sheet piling to uniform elevation at top of excavation.

B. Sheet Piling installation shall meet the designated structural monitoring and vibration limitations generated for the Project and approved by the Commissioner.

3.04 BRACING

A. Bracing: Locate bracing to clear columns, floor framing construction, and other permanent work. If necessary to move brace, install new bracing before removing original brace.

B. Do not place bracing where it will be cast into or included in permanent concrete work, unless otherwise approved by Commissioner.

C. Install internal bracing, if required, to prevent spreading or distortion of braced frames.

D. Maintain bracing until structural elements are supported by other bracing or until permanent construction is able to withstand lateral earth and hydrostatic pressures.

3.05 REMOVAL AND REPAIRS

A. Wherever possible remove excavation support and protection systems when construction has progressed sufficiently to support excavation and bear soil and hydrostatic pressures. Remove in stages to avoid disturbing underlying soils or damaging structures, pavements, facilities, and utilities.

B. If removal will cause adverse effect leave excavation support and protection systems permanently in place.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The work of EXCAVATION SUPPORT AND PROTECTION shall not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the Work of EXCAVATION SUPPORT AND PROTECTION shall be included in the contract lump sum price as shown in the Schedule for Prices for STRUCTURAL WORK.

4.03 PAY ITEM ACCOUNT NUMBER Structural work: 030000

END OF SECTION 31 50 00

SECTION 31 50 01

PERMANENT SUPPORT OF EXCAVATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes steel sheet piling for design included in the Contract Documents for the permanent support of excavation (SOE) at the northwest corner of the Damen and Lake intersection.

B. This section does not include performance-based earth support (Design by Contractor's Engineer) at other areas or temporary utility support. Refer to 31 50 00 – Excavation Support and Protection.

C. This work includes all labor, materials, accessories, tools, and equipment required to furnish, place, and maintain the permanent SOE to the extent required.

D. Related Sections include following:

1. Section 02 16 10 – Monitoring Adjacent Structures During Construction.
2. Section 03 30 00 – Cast-in-Place Concrete.
3. Section 31 09 13 – Monitoring Track structures During Construction.
4. Section 31 20 00 – Earth Moving.
5. Section 31 23 10 – Excavation, Trenching and Backfilling (Utilities)
6. Section 31 23 19 – Dewatering Excavations.
7. Section 31 50 00 – Excavation Support and Protection.

E. Definitions:

1. Definition of project terms and abbreviations are found within Specification Section 01 35 00.

1.03 STANDARDS

A. ASTM International:

1. ASTM A36/A36M – Standard Specification for Carbon Structural Steel.

2. ASTM A572/A572M - Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.

B. American Welding Society (AWS):

1. D1.1 – Structural Welding code, Steel for all welding, inspection of welds, and testing of welds.

1.04 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at the project site at least thirty days prior to the start of the permanent SOE installation.

1. At a minimum, preinstallation conference shall be attended by the Commissioner's Project Manager, Structural EOR, Civil/Geotechnical EOR, Contractor's Superintendent, permanent SOE installer, earthworks installer, dewatering installer, and concrete encasement installer.

a. Verify availability of permanent SOE installer's personnel, equipment, and facilities needed to make progress and avoid delays.
b. Review condition of site to be dewatered, including coordination with temporary erosion-control measures and temporary controls and protections.
c. Review geotechnical report.
d. Review proposed site clearing and excavations.
e. Confirm coordination with the excavation and backfilling, dewatering, and concrete placement activities.
f. Review existing utility surveys and preconstruction inspections, and surveys.
g. Review requirements for observation, testing, and monitoring of the permanent SOE.
h. Coordination for interruption, shutoff, capping, and continuation of utility services.

1.05 SUBMITTALS

A. Submit the following according to conditions of the construction contract and Division 1 Specification Sections.

B. Preconstruction: Submit to the Commissioner the following prior to commencement of the work:

1. Submit the following action submittals for review and approval:

a. Qualifications:

1) Manufacturer: Company specializing in manufacturing products specified in this section with minimum 10 years documented experience.

2) Permanent SOE Installer: Company specializing in performing work of this section with minimum 10 years documented experience.
3) Welders and Welding Procedures: AWS D1.1 qualified within previous twelve months.

b. Contractor means and methods including:

1) Include a written plan for SOE including sequence and coordination with other site work.
2) Description of equipment to be used for installing the permanent SOE.

c. Product Data: For each type of product.

1) Include material descriptions, performance properties, and dimensions of individual components and profiles.
2) Submit material certification, details of sheet piling, mill test reports, and piling driving equipment certification.
3) Include manufacturer's data sheets on cranes and driving equipment.

d. Shop Drawings and Mill Certificates:

1) Shop drawings and mill certificates for all sheet piling.
2) Indicate location and extent of sheet piling, details of top protection, tip reinforcement, splices, and cut-off method.
3) Include complete dimensions and details of sheet piling sections.
4) Include sequence of driving and detailed drawings of templates or other temporary guide structures.
5) Submit list and size of proposed equipment including cranes, driving equipment, protection caps, and other installation accessories.
6) Submit detailed procedures and features for protection of existing structures or other installations.
7) Include details of storage and handling procedures.

C. Field Quality Control: Submit the following information submittals as specified or per request of the Commissioner during construction. Keep records throughout construction for all of the following:

1. Reference Section 02 16 10 – Monitoring Adjacent Structures During Construction and Section 31 09 13 – Monitoring Track Structures During Construction for survey and monitoring work.
2. Survey-Work Benchmarks: Resurvey benchmarks regularly during installation of the permanent SOE, excavation progress, and for as long as excavation remains open. Maintain an accurate log of surveyed elevations and positions for comparison with original elevations and positions.
3. Monitor permanent SOE daily during excavation progress and for as long as excavation remains open. Promptly correct detected bulges, breakage, or other evidence of movement to ensure that permanent SOE remains stable. Promptly notify Commissioner changes in elevations or positions occur, or if cracks, sags, or other damage is evident in adjacent construction.

D. Closeout:

1. Provide the following record documents:

a. All records from Field Quality Control program.
b. Record Drawings: Identify locations and depths of capped utilities, permanent SOE, and other subsurface structural, electrical, or mechanical conditions.

1.06 PROJECT CONDITIONS

A. Perform test pit excavations to locate buried structures prior to installing the permanent SOE.

B. Proceed with caution in areas of utilities. Expose them by hand excavation, vacuum, or by other methods acceptable to the Commissioner and utility owner. The Contractor is responsible for any damage to utilities caused by his operations.

C. Interruption of Existing Utilities: Do not interrupt any utility serving facilities occupied by the Commissioner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:

1. Notify Commissioner no fewer than 48 hrs (two days) in advance of proposed interruption of utility.
2. Do not proceed with interruption of utility without Commissioner's written permission.

D. Survey Work: Refer to Specification 02 16 10 – Monitoring Adjacent Structures During Construction, and Specification 31 09 13 – Monitoring Track Structures During Construction.

PART 2 - PRODUCTS

2.01 MATERIALS

A. General: Provide materials that are either new or in serviceable condition.

B. Steel Sheet Piling: ASTM A572 Grade 50; with continuous ball and socket interlocks. Steel sheet piling and interlocks shall not have excessive kinks, camber, or twists that would prevent the pile from free sliding.

C. Welding Electrodes: E70XX.

PART 3 - EXECUTION

3.01 PREPARATION

A. Contractor must verify all dimensions and conditions in the field prior to fabricating and installing sheet piling. Notify the Commissioner of any major discrepancies.

B. Pre-excavate 3 ft deep to remove obstructions prior to installation of permanent SOE. Locate all existing buried utilities prior to installing sheeting. Protect structures, utilities, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards that could develop during permanent SOE installation.

C. Install temporary vehicle barricades to prevent traffic access to excavation. Reference Maintenance of Traffic (MOT) plans.

D. Verify equipment on site conforms to approved Submittal.

E. Use driving method that will not cause damage to nearby structures.

F. Notify adjacent and affected land owners and building occupants minimum seven days before proceeding with the Work.

G. Verify cranes will not impact CTA operations or overhead utilities. All work in this zone needs to be coordinated with CTA requirements. Limited work times must be considered.

H. Protect structures including overhead and buried utilities near the Work, from damage.

I. Leave permanent sheet piling in place as part of completed Work.

3.02 PILE HAMMER

A. Use pile driving hammer complying with requirements indicated on approved submittals.

B. Keep hammer in good mechanical condition.

C. Operate hammer at speed and pressure recommended by manufacturer.

D. Use protective cap during driving to prevent damage to top of sheet piling.

3.03 TEMPLATES

A. Provide template or driving frame suitable for aligning, supporting, and maintaining sheet piling in correct position during setting and driving.

B. Structural frame sufficiently rigid to resist lateral driving forces.

C. Provide wood blocking to bear against webs of alternate sheet piling.

D. Provide outer restraints to prevent sheets from warping or wandering.

E. Provide visible markings on templates to verify correct sheet piling location and direction.

3.04 SHEET PILING

A. Before starting excavation, install one-piece sheet piling lengths with continuous vertical interlocks to form a continuous barrier.

B. Accurately place the sheet piling, using templates and guide frames unless otherwise recommended in writing by the sheet piling manufacturer. Install steel sheet piles with an impact or vibratory hammer using methods that maintain continuous interlock. Accurately align exposed faces of sheet piling to vary not more than 2 in. from a horizontal line and not more than 1:48 out of vertical alignment.

C. Drive Z-piling with male interlock forward or leading and drive Z-piling in pairs.

D. Incrementally drive sheets or pairs of sheets so tip of any sheet or pair is not more than 4 ft (1.2 m) below adjacent sheet or pair.

E. Jetting or predrilling of sheet piling is not permitted.

F. Drive sheet piling to minimum tip penetration.

G. Do not damage sheet piling during driving operations.

H. Once excavation is backfilled to within 24 in. of grade cut steel sheeting to depth shown on the drawings.

3.05 WELDING AND SPLICING

A. Perform welding in accordance with AWS D1.1 for shielded metal arc welding.

B. Splice sheet piling sections with complete penetration butt weld.

C. Use jig or alignment device during welding to maintain required shape and alignment.

D. No more than one splice for each sheet pile.

3.06 REPAIRS

A. Promptly repair damages to adjacent facilities caused by installation or faulty performance of the permanent SOE.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The work of PERMANENT SUPPORT OF EXCAVATION shall not be measured for payment.

4.02 PAYMENT

A. No separate payment shall be made for the work covered in this Section. Payment for the Work of PERMANENT SUPPORT OF EXCAVATION shall be included in the contract lump sum price as shown in the Schedule of Prices for PERMANENT EXCAVATION SUPPORT AND PROTECTION.

4.03 PAY ITEM ACCOUNT NUMBER

A. Structural Work: 030000.

END OF SECTION

SECTION 31 63 33

DRILLED MICROPILES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. General:

1. Scope of Work consists of all drilled micropile foundations; designed, furnished, installed, and tested in accordance with these specifications.
2. Scope of Work includes the removal and disposal of all special and non-special waste generated as a result of micropile installation.

B. Related Sections: The following sections contain requirements that relate to this Section.

1. Section 02 16 10 – Monitoring of Adjacent Structures During Construction.
2. Section 03 20 00 – Concrete Reinforcement and Embedded Items.
3. Section 03 30 00 – Cast-in-Place Concrete.
4. Section 05 10 30 – Structural Steel.
5. Section 31 09 13 – Monitoring Track Structures During Construction.

C. Definitions:

1. Definition of project terms and abbreviations are found within Specification Section 01 35 00.
2. Nonproduction Pile – Nonproduction piles are piles that are not incorporated into the substructure, such as test piles, which are abandoned after testing has been completed. Nonproduction piles must be installed using the same equipment, methods, and materials as production piles. Test piles may be used as a production pile if not loaded to failure during the load test.
3. Production Pile – A pile, which will be incorporated into the structures foundation.

1.03 REFERENCES

A. Acronyms for reference standards are defined in Section 01 42 00.

B. ACI: ACI 318/318M, "Building Code Requirements for Structural Concrete."

C. AISC "Specification for Structural Steel Buildings", includes ASD and LRFD design.

1. AISC 360: Specification for Structural Steel Buildings.

D. API (American Petroleum Institute) 5CT Specification for Steel Oil Well Pipe having internally machined threads for coupling pipe.

E. ASTM A106 – Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.

F. ASTM A370 – Standard Test Methods and Definitions for Mechanical Testing of Steel Products.

G. ASTM A722 – Standard Specification for High-Strength Steel Bars for Prestressed Concrete.

H. ASTM A615 – Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.

I. ASTM C109 – Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (using 2-in. cube specimens).

J. ASTM C150 – Standard Specification for Portland Cement.

K. ASTM D1143 – Standard Test Methods for Deep Foundations Under Static Axial Compressive Load.

L. ASTM D3689 – Standard Test Methods for Deep Foundations Under Static Tensile Load.

M. City of Chicago Department of Buildings Code, Division 18, Chapter 13-132 with Memorandum, "Pile Deep Foundation," dated 15 July 2017.

N. Federal Highway Administration "Micropile Design and Construction Guidelines Manual" Report No. FHWA-SA-97-070.

O. AASHTO Standard Specification 17th Edition, 2005.

P. AASHTO LRFD Bridge Design Specifications.

Q. "Bending Strength of Threaded Micropile Connections" by Steven R. Musselman, J.H. Long, N. Carroll, and S. Farr.

R. IDOT Bridge Manual.

S. IDOT Standard Specification for Road and Bridge Construction, including the current Supplemental Specifications and applicable Guide Bridge Special Provisions.

1.04 QUALITY ASSURANCE

A. Micropile Delegated Design: Refer to the project details for the micropile design axial compression, tension, and lateral loads.

B. The Contractor is solely responsible for the design of all micropiles and their connections. All micropiles shall be designed and have calculations performed according to the items noted within the Submittals Section C of this specification and the drawings.

C. The work of this Section shall be performed by a company which specializes in the type of micropile installation work required for this Project, with a minimum of 10 years of documented successful installation experience and shall be performed by skilled workmen thoroughly experienced in the necessary crafts.

1. Work shall be performed in compliance with Owner's insurance underwriters' requirements

D. Unless otherwise directed, the Contractor will select the micropile type and installation method, and design the required length, diameter, thickness, reinforcement, embedment plates, welding, and connecting elements, and grouting as necessary to resist the indicated design loads.

E. The Contractor is responsible for installing in accordance with the testing subsection of this Specification.

F. Contractor’s proposal will explain in detail the materials, methods, and design assumptions that will be employed for the scope of Work covered by this specification.

G. Testing Agency Services: Required as specified in Section 01 40 00 Quality Control, and herein.

H. Contractor's Quality Assurance Responsibilities: Contractor is solely responsible for quality control of the Work

1. Contractor's Soils Consultant: The Contractor shall meet all the requirements of the Geotechnical Engineer and Testing Agency.

1.05 SUBMITTALS

A. Procedures: Furnish submittals in accordance with general requirements specified in Section 01 30 00 Submittals.

B. Load Test Plan for Drilled Micropiles: Submit the load testing plan and detailed procedure. Testing shall be performed per the City of Chicago Pile Deep Foundation Memorandum and ASTM D1143 and ASTM D3689 procedures described within. Testing procedure will include, but not be limited to:

1. Set up and breakdown of testing equipment.
2. Testing procedure.

3. Test locations and clash detection with utilities.
4. Final testing report including a statement if the load test passed or failed.
5. Pile load test schedule and acceptance criteria per Part 3 Execution – Pile Load Tests.

C. Shop Drawings: Submit for Owner Representative's review thirty calendar days prior to the commencement of the Work. Furnish shop drawings for the fabrication and installation of the Work.

1. Indicate the piling types, allowable compression and tension loads, configurations and layouts, reinforcement, embedment plates, accessories, individual piling numbers, drilling shoes, and other relevant items.
2. Pile details shall include, but not limited to, nominal diameter, length, embedment length size and length of permanent casing, grout strength, reinforcement, pile top attachment, splices in piles, splices in reinforcement, post grout tube, grouting pressures, and detail of rock anchors.
3. Layout drawings showing the proposed sequence of pile installation. Coordinate the sequence with the proposed phasing and scheduling.
4. Details of placement, splicing, and centering devices for steel reinforcement.

D. Product Data: For each type of product indicated, including, but not limited to, the following:

1. Welding filler metals and fluxes.
2. Steel reinforcement.

E. Certifications: Submit for Owner Representative's information. Furnish certified reports for the following:

1. Certification to Examination of Site and Records: Before proceeding with the Work, submit certification in acceptable form signed by the Contractor, stating that careful examination has been made of the site, existing structures records of utility lines, test boring records, soil samples, subsurface exploration reports by the subsoil exploration consultant, the Contract Documents.
2. Casing Mill Test Reports: Signed by manufacturer certifying that the casing chemical and physical properties comply with project requirements, or random coupon testing of a minimum of three samples per 50 pile segments by the supplier. A letter must be provided by the supplier verifying the lot-coupon relationship.
3. Grout Mix Design: Furnish certified report identifying the design mix, the mix properties, and the design mix test results.
4. Welding certificates.
5. Welding Procedure Specifications including Qualification Test Reports for welds qualified by test, for each class of weld to be incorporated in the Work.

F. Provide evidence that the ultimate strength of the threaded joints complies with requirements shown in Drawings by one of the following methods:

1. If the evidence will be provided by the testing, then the testing apparatus setup and procedures must be reviewed and approved by the Commissioner.
2. If the evidence will be provided by the SSE's calculations, then submit the signed and sealed calculations performed by the Contractor's SSE.

G. Structural Calculations by SSE: Submit to the Commissioner the following items signed and sealed by a licensed Structural Engineer in the State of Illinois. Furnish engineering design calculations for each piling design.

1. The micropiles will be designed by the micropile Contractor to meet the specified loading conditions, as shown on the Contract Documents and to meet all the requirements of City of Chicago Building Code and the City of Chicago Pile Deep Foundation Memorandum.
2. Design all micropiles using the procedures contained in the FHWA "Micropile Design and Construction Guidelines Manual" Report No. FHWA-SA-97-070. Material stresses shall not exceed those provided in the City of Chicago Pile Deep Foundation Memorandum dated 15 June 2017.
3. Refer to the Geotechnical Engineer's report for additional design requirements.

H. Provide Process Plan that contains:

1. Details of equipment and procedures for pile installation including, but not limited to, consecutive steps and the approximate time required for each step.
2. Procedures for advancing through soils, timber piles, boulders, and other obstructions. Methods to be used to control and verify pile positions and alignment.
3. Procedures for control and removal of all spoil.
4. Drawings that show that the specified work can be performed under limited headroom conditions and as close to obstructions as site conditions warrant to install the piles at the locations shown on the Drawings.
5. Procedures and equipment for placing grout.
6. Details of post-grouting equipment and procedures including the method, procedure, and equipment required.
7. Procedures such as temporary casing to maintain an open hole during drilling, and the method to assure that the drilling hole has not collapsed and has the minimum required diameter before grouting. Methods to be used to measure the minimum required diameter.
8. Methods to flush the drilled hole and methods and equipment for measuring columns of grout placed in each pile.
9. Detailed procedures for pile load tests including, but not limited to, consecutive steps and the approximate time required for each step.

I. Quality Control Testing and Inspection Reports: Submit for the Commissioner's information. Furnish reports for the specified Source Quality Control and Field Quality Control inspections and tests.

1. In addition, furnish a detailed written description of the pile construction procedures, drilling methods and equipment to be used in the Work.

J. As-Built Pile Surveys: Provide an as-built record of all pile locations and their top Elevation:

1. Date constructed.
2. Location.
3. Grout mix used.
4. Tested strength of grout.
5. Depth drilled.

6. Total grout used.
7. Size and type of steel casing.
8. Grout injection pressure.
9. Log of soil/rock drilled.
10. Final base and top elevation of outer casing.
11. Elevations for all splices.
12. Splice types.
13. Testing reports for weld splice testing.
14. For tension piles, provide mill certs for tension rod and couplers.

1.06 CONTRACTOR QUALIFICATION

A. The work of this Section is specialized. The Contractor performing this work must be a reputable firm regularly engaged in the design and installation of bored-in piles. The Contractor must have successfully completed at least five projects of similar size and complexity in this type of installation. The Contractor must have experience installing and designing bored piles of high capacity (design capacity of 200 tons per pile in compression and 75 tons in tension or greater), installation of piles through obstructions and using duplex and nondisplacement drilling techniques, and load testing experience of similar capacity piles. The Contractor must submit load test results for at least three previous successful micropile load tests from the five projects as required above.

B. The Contractor must identify the design consultant and owner for each referenced project for which this type of work was performed. The Contractor must provide proof to the Engineer of each project for approval no later than ten days after Notice to Proceed. Such evidence must include the name and location of the project, client name and address, and the name and telephone number of a representative of the consultant and owner for whom the work was performed and who can attest to successful completion of the work.

C. A project summary must be included for each referenced project. The project summary must contain the start date and completion date of the project, total contract amount for the bored in piles and a detailed description of the project, site conditions, and subsurface conditions. The project description must include the nature of the project, details of the bored-in pile design, installation techniques, total length of bored-in piles installed, design capacity and load test results, individual length of pile installed, and any other information relevant to demonstrating the Contractor's qualifications.

D. Assign an experienced, full-time supervisor who has been in responsible charge of supervising bored-in pile operations for at least five projects in the last 3 years. The supervisor must be present at the work site at all times during bored-in pile operations. Provide written verification of the supervisor's experience. The qualifications of the supervisor will be subject to review and approval by the Engineer.

1.07 DELIVERY, STORAGE AND HANDLING

A. It is the Contractors responsibility to store all piles and pile materials on site safely, securely, and in a manner that does not damage or overload the existing structure.

B. The Contractor is responsible for verification of all temporary loading conditions on the existing structure. Demolition activities on the site may cause temporary reductions in loads and stability of the existing structure.

PART 2 - PRODUCTS

2.01 STEEL PIPE PILES

A. Steel Pipe for Drilled Micropiles: Open end steel pipe with machined internal flush couple threaded joint with physical properties equal to or exceeding API oil field casing Grade N-80, 5CT N80. Physical properties must be determined by coupon tests of random samples of a number specified within Part 1. A letter must be provided by the supplier verifying the lot-coupon relationship. Drill tooling and methods should be selected by the Micropile Contractor based on previous experience in the soil and rock conditions presented at the site. The Contractor must have the casing shop flush-joint threaded in predetermined lengths. Free from mill scale, flake, rust, or pitting.

1. API 5CT Grade N80 casing shall not be spliced with welded joints.

B. Cutting Head and Drilling Shoes: Provide shoes or tip reinforcement as required. Hardened structural steel, unless higher-grade steel is required by the specific design. Secure shoes to pile so as not to adversely affect pile alignment during drilling.

C. Sacrificial bits shall be tricone-type permanently affixed to the lead pipe section. The bit should be selected to allow excavation of soil and rock using external flush drilling techniques. Bits may be oversized relative to the casing diameter by up to 2 in.

2.02 MATERIALS

A. Steel Casing: API 5CT Grade N80 Steel Pipe, F_Y = 80 ksi

1. Charpy V-Notch satisfying API 5CT Section 7.3.1.

B. Portland Cement: ASTM C150, Type 1.

1. Cement furnished must be in paper bags or bulk tanker and clearly labeled as to type and manufacturer. A sufficient quantity of cement must be stored at or near the site of the work to ensure that grouting operations will not be delayed by shortage of cement. The use of bulk cement will be permitted provided the Contractor employs methods of handling, transportation and storage that are satisfactory to the Engineer.

C. Mixing Water: Clean, potable, and free from deleterious substances, which would impair the Work.

D. Steel Reinforcement Bars: ASTM A722, Grade 90 or 150 (as necessary for design or load test).

1. Provide bar reinforcement meeting the requirements of Section 03 20 00.
2. Reinforcement bars shall not be epoxy coated.
3. Rebar couplers are to be threaded and are to be rated at 1.25 times the yield strength of the rebar being spliced.

E. Admixtures:

1. Fluidifier/expansion admixture may not be used in the cement grout unless it is approved by the Engineer.

2.03 GROUT MIX DESIGN

A. Testing Agency: Design each type of mix required in accordance with ACI 301, either by Trial Mix or Previous Experience methods.

B. Improper Mix: Provide mix design and samples of the grout mix to the Owner's Independent Testing Agency for review.

2.04 GROUT MIX PROPORTIONS

A. Proportioning: Produce job-use grout of the type and strength indicated, subject to the following minimum requirements.

1. Minimum Design Strength: 5,000 psi.

PART 3 - EXECUTION

3.01 JOB CONDITIONS

A. The Contractor must, throughout the duration of the construction work, coordinate his work and cooperate with authorities and other contractors in order to allow ongoing operations to continue undisturbed throughout the micropile pile work. The Contractor must contain his micropile pile and grout products, drill cuttings, drilling fluid, and dust, from his operations in such fashion as to not interfere with adjacent operations.

3.02 EXAMINATION

A. Verification of Conditions: Examine the areas to receive the Work and the conditions under which the Work would be performed. Contractor shall remedy conditions detrimental to the proper and timely completion of the Work. Do not proceed until unsatisfactory conditions have been corrected.

3.03 PROTECTION OF EXISTING UTILITIES

A. Before installing piles adjacent to any existing utilities, notify the Utility Owner to ensure the protective Work will be coordinated and performed by the Contractor in accordance with the requirements of such owner of the utility involved. If any existing service lines, utilities and utility structures to remain in service are uncovered or encountered during these operations, protect from damage and provide support if necessary.

B. Should uncharted or incorrectly charted piping or other utilities be encountered during piling operations, immediately notify the Owner, the Owner Representative, and the Utility Owner. Cooperate with the Owner and the Utility Owner in keeping their respective services, utilities and facilities in operation. Repair damaged utilities to the entire satisfaction of the Owner and utility owner concerned.

C. Use a drilling method which will not cause damage to all structures and protect structures near the work from damage.

D. During grouting operations, the Contractor must take such precautions as may be necessary to prevent dust, drill cuttings, equipment exhaust, oil, wash water, and grout from defacing or damaging any adjacent structure or equipment. Any accidental unforeseen spillage of grout must be cleared immediately to reduce the possibility of staining existing structures.

E. Protection must include the covering with plastic sheeting or similar material of all structure walls near drilling and grouting operations. The Contractor must furnish such pumps as may be necessary to care for waste water and grout from his operations, and clean up all waste resulting from his operations.

3.04 PILE INSTALLATION, GENERAL

A. Equipment: Use equipment of type generally used in standard practice for the installation of drilled structural steel pipe micropiles and suitable for the soil strata to be encountered. Employ grouting equipment capable of continuous mechanical mixing to produce a uniform and thoroughly mixed grout.

B. Pile Locations: Carefully locate to the lines and spacing shown. Install to the plumb or battered position, unless otherwise noted on the drawings.

1. Do not install piles within 20 ft-0 in. of concrete less than three days old.

C. Center of Gravity: Conform to the locations indicated for each group of foundation piles.

D. Drilling Procedure: Drill piles to the minimum depth and drilling resistance as established by the pile load tests and Contractor’s design.

E. Handling and Installing Extra Long Slender Piles: Prevent overstress or leading away from a plumb or true position.

F. Pile Heaving: If piles heave because of drilling other piles nearby, drill the affected piles to either the original resistance, or original tip elevation, or both, as directed.

G. Pile Cut-Off: After drilled to acceptable completion, cut off each pile square at the cut-off grade lines and remove surplus material from the site. Make cut-off surface level, free from distortions or damage due to drilling or cut-off procedures. Correct damaged pile heads by acceptable methods.

H. Piles Damaged, Mislocated, or Out of Alignment: Withdraw and replace by new piles, or cut off and abandon and install additional piles. Contractor shall be responsible for additional costs to other related structural components, such as concrete caps and grade beams or reinforcing modifications due to piles damaged, mislocated, or out of alignment, unless damage, mislocation, and/or misalignment is due to hitting or intentionally avoiding unforeseen existing below-grade obstructions.

3.05 DRILLING STEEL PIPE MICROPILES

A. Drilling Procedure: Sequence the pile drilling in each pile cluster to prevent significant displacement. Drill all piles in cluster before any foundation concrete is poured.

B. Soil excavation shall be accomplished with a retractable drill string or sacrificial tricone bit using external flush methods. Rock excavation shall be accomplished with a downhole hammer or sacrificial bit. If a downhole hammer is used, excavation shall be performed so as not to adversely affect the integrity of the rock mass, or reduce the axial capacity of adjacent rock sockets (i.e., the hammer energy shall be such that it does not shatter the rock outside the socket).

C. Maximum Deviation from Indicated Locations: 3 in. for any pile from theoretical location measured at the cut-off elevation. Center lines of piles plumb within a tolerance of 2º measured with pile above the ground in the leads.

D. Cut Off: Grind the pipe cut-off surface level above the existing concrete footing using a grinder machine.

E. Cleaning: After drilling, clean the interior of the steel pipe by flushing with water.

F. Grouting: After cleaning the interior of steel pipe is completed, place grout continuously from the bottom to the top of the pile cut off location shown in the drawings. Each pile drilled at an individual pile cap shall be grouted and allowed to harden for a minimum 24 hrs prior to drilling or installing the pipes at adjacent caps.

3.06 GROUTING

A. The cement in grout shall not contain lumps or other indications of hydration. Admixtures, if used, shall be mixed in accordance with the manufacturer’s recommendation.

B. The grouting equipment shall produce a grout free of lumps and undispersed cement. The pump shall be equipped with a pressure gauge to monitor grout pressures. The pressure gauge shall be capable of measuring pressure of at least 150 psi or twice

the actual grout pressures used by the Contractor, whichever is greater. The grouting equipment shall be sized to enable the grout to be pumped in one continuous operation. The mixer should be capable of continuously agitating the grout.

C. The micropile shall be tremie grouted by injecting grout from the lowest point of the drill hole to fully displace drill and cleaning water. The grout may be pumped through grout tubes, casing, hollow-stem-augers or drill rods. The quantity of the grout placed shall be recorded.

D. Upon completion of tremie grouting, micropiles shall be pressure grouted to fully fill the annular space surrounding the casing in the rock socket and, to the extent possible, the annulus through the height of the soil overburden. Pressure grouting should continue until either pressure gauges indicate no injection of grout is occurring, or clean grout is observed flowing from the annular space outside the casing at the ground surface. Grout return at the surface is not required. The grout pressures and grout takes shall be recorded and controlled to prevent excessive heave in cohesive soils or fracturing of rock formations.

E. Each pile drilled at an individual pile cap shall be grouted and allowed to harden for a minimum 24 hrs prior to drilling or installing the next pipe under the adjacent cap.

F. After grouting, the micropile shall not be loaded for a minimum of three days.

3.07 REINFORCING BARS PLACEMENT AND SPLICING

A. Surfaces of the reinforcement (bars and/or casings) shall be free of deleterious substances, such as soil, mud, grease, or soil that might contaminate the grout or coat the reinforcement and impair bond.

B. Centralizers and spacers shall be provided at 10 ft centers maximum spacing. The upper and lower most centralizer shall be located a maximum of 5 ft from the top and bottom of the micropile.

C. Lengths of reinforcing bars to be spliced shall be secured in proper alignment and in a manner to avoid eccentricity or angle between the axes of the two lengths to be spliced. Appropriate size couplers may be used with threaded reinforcement. Threaded pipe casing joints shall be located at least two casing diameters (OD) from a splice in any reinforcing bar. When multiple bars are used, the bar splices shall be staggered at least 1 ft.

3.08 POST GROUTING

A. Provide the equipment and materials to perform post grouting. Perform post grouting as required on the reviewed shop drawings or as directed by the Engineer.

B. Perform post grouting after the grout for the bored-in pile has set.

C. The work consists of pumping grout under pressure into a post grout tube cast into the pile. The grout will exit the post grout tube one port at a time, with the port being isolated using a packer system.

D. Record the pressure at which the grout was pumped and the volume pumped through each port.

3.09 CONSTRUCTION TOLERANCE

A. Install the piles so that the center of each bored-in pile does not vary from the plan location by more than 3 in. Do not allow the bored-in pile to vary from the vertical or established batter by more than 1/8 in. per foot, as measured aboveground. Any variation caused by unforeseen conditions needs to be approved by the Engineer.

B. Top elevation of micropile shall be plus 1 in. minus 2 in. from vertical elevation indicated on drawings or where ordered by the Authority.

C. Center of reinforcing steel shall not be more than 3/4 in. from indicated location on drawings.

D. If the soil at the pile tip is post grouted, monitor the elevation of the pile top during post grouting. Do not permit pile uplift to exceed 1/4 in.

3.10 FIELD QUALITY CONTROL

A. Drilled Pile Load Tests:

1. Include the following tests in the Work:

   a. (1) Compression Load Test for a 295 kip (compression) micropile.
   b. (1) Tension Load Test for a 45 kip (tension) micropile.

2. Compression and tension load test will be on different test piles unless the Delegated Design Engineer's calculations demonstrate that the compression pile required rock socket depth is suitable to resist the tension load.
3. Install test piles with the same equipment and in the same manner as the permanent piles, to estimated tip elevations and drilling resistances in the soil which will develop the required piling capacities as noted on the drawings and in accordance with the geotechnical parameters.
4. Test loads may be applied either using hydraulic jacks reacting against a system of anchor piles or a gravity load arrangement. Anchor piles shall be at least 8 ft from the test pile. The jack shall be centered on the axis of the pile and shall be of design and maintained in such a condition that it will develop the required test loads, maintain them and release them as specified herein.
5. The micropile load test program proposed by the Contractor must be in conformance with ASTM D1143 Static Load Test Procedure B for all friction piles in compression and the Quick Test Loading Procedure A for rock bearing compression piles; ASTM D3689 Procedure B – Maintained Test for tension piles, except as modified by the City of Chicago Building Code and herein, and must at a minimum contain the following information:

   a. Type and Accuracy of apparatus for measuring load.
   b. Type and Accuracy of apparatus for applying load.
   c. Type and Accuracy of apparatus for measuring pile deformation.

d. Type and capacity of the reaction load system.
e. Hydraulic jack calibration report.
f. Micropile Load Test Loading Schedule and Acceptance Criteria.

6. The following clarifications shall be used for ASTM D-1143 Quick Test Loading Procedure A:

   a. The Structural Engineer who is responsible for the micropile design must determine the anticipated failure load, but must not be less than 2.0 DL (Design Load).
   b. All load time intervals are 15 min.

7. If the capacity of compression piles is only developed by skin friction (or side resistance), it is acceptable to load test these piles in axial tension for easier testing apparatus setup.

8. For a pile subjected to tension, the uplift capacity of a single micropile shall be determined in accordance with ASTM D3689. Where uplift load tests are performed, the maximum allowable uplift load shall not exceed the ultimate load capacity divided by a factor of safety of two.

B. The Contractor shall modify the design and install and test another pile at their own expense if the test pile fails to give acceptable results. Contractor also guarantees that they will repair or replace at their own expense all structural damage caused by inability of the Micropiles to satisfactorily support the working loads for a period or two years.

C. Contractor's Drilled Pile Surveys: Perform surveys to obtain accurate information of following items for each pile.

1. Survey pile locations and pile length, daily and submit reports for review.
2. Measure the final cut off elevation.
3. Measure the horizontal location of top of pile at the final cut-off elevation.
4. Make a continuous survey of completed piles and record the heave of each pile in a pile cluster due to drilling of pile within the cluster. Submit record of heave survey on a daily basis.

D. Grout Testing:

1. During construction, grout mix samples selected at random must be taken daily (six samples per day)
2. for testing. The Engineer will control sample selection. The Contractor will be responsible for testing the samples; the cost of testing is deemed to be included in the cost of bored-in piles.
3. The samples must be molded, cured in a properly constructed curing box supplied by the Contractor, and tested in accordance with ASTM C109, and must reach a compressive strength after seven days equal to at least 60% of the design strength.
4. If this requirement is not met, the Contractor must modify the proportions of the mix subject to the approval of the Engineer.
5. The Engineer may also require the Contractor to modify the mix design if an excessive amount of grout is lost from a pile hole into voids in the in-place

materials. Materials must be accurately measured by weight or volume prior to mixing.

6. Each batch of grout must have the same volume and contain the same whole number of sacks of cement, unless a modification is approved by the Engineer. Time of mixing must be not less than 3 min.
7. If agitated continuously, the grout may be held in the mixer or agitator for a period not exceeding three hours at temperatures below 70°F and for a period not exceeding 2 hrs at higher temperatures.
8. If there is a lapse in pumping of grout, the grout must be recirculated through the pump or through the mixer drum (or agitator) and pump.
9. Retempering of grout will not be permitted

3.11 PILE ACCEPTANCE CRITERIA

A. All piles must meet construction tolerance criteria.

B. All piles must be installed in accordance with the dimensions and procedures shown in the approved submittals and specified herein.

C. Acceptance Criteria must contain the following items at a minimum:

1. For building structures, use the acceptance criteria as shown in the Chicago Building Code (CBC) Pile Deep Foundations Code Memorandum.
2. For track and bridge structures:

    a. Total vertical movement at top of the pile at the first compression or tension 1.0DL test load does not exceed the maximum allowable movement. The maximum allowable movement must be determined by the Structural Engineer based on structural design requirements but no more than the settlement limits in Design Criteria.
    b. Failure does not occur at the anticipated failure load. Failure is defined as pile movement exceeding the failure criterion determined using Davisson Method as specified in AASHTO LRFD 7th Edition Figure C10.7.3.8.2-1.

3. If the micropile load test fails to meet the design requirements, the Contractor must determine the cause, and must modify the micropile and/or installation methods and retest the new system as directed by the Commissioner.

3.12 UNACCEPTABLE MICROPILES

A. Unacceptable micropiles are piles that are rejected by the Engineer because of damage, failure to advance through obstructions, misallocation, misalignment, or failure to install the pile to the proper bearing stratum. Submit a written plan of action to the Engineer for approval, showing how to correct the problem and prevent its reoccurrence. Repair or augment the pile to the satisfaction of the Engineer to make it acceptable. To mitigate and/or to remedy unaccepted piles, the Contractor may be required to provide additional piles or supplement piles to meet specified requirements at no cost to the Engineer.

3.13 CLEANUP

A. Upon completion of daily grout operations, excess grout in the hoses, mixer, and grout pump must be trapped in a confined section of the construction site and immediately removed offsite.

B. The Contractor must clean up all waste resulting from his operations and restore any damage or defaced structures to original condition. The site ground must be cleaned and restored to its original condition

3.14 MONITORING ACTIVITY

A. Incorporate micropile monitoring criteria into Specification Section 02 16 10 and Section 03 20 00.

B. Testing Agency: The testing agency, engaged by the Commissioner at the Contractor's expense, will perform the following activities to monitor the Contractor's Quality Control Program. The monitoring activities are at the Commissioner's discretion and in no way relieve the Contractor of sole responsibility for maintaining the Quality Control Program.

C. Preconstruction Survey: Prior to the commencement of pile drilling operations, prepare and record a visual and photographic record of existing conditions of adjacent existing construction for the Commissioner's record.

D. Pile Load Test Records: Review Contractor's test pile program, including verification of anchor piles, gravity load boxes, and jack calibration. Record the full installation sequence of the test piles. Measure the settlement with a minimum of two dial gages having 0.001 in. accuracy and additional instrument survey points, and record immediately before and after each increment of the test load is applied, and immediately before and 24 hrs after the total load is removed.

E. Daily Piling Inspection: Perform the following tests and inspections for all piling installation operations:

1. Drilling Procedures: Review the Contractor's proposed piling design, drilling lengths, drilling procedures and sequences, equipment, and materials.
2. Visual Inspection: Perform full-time visual inspection of all piling installation.
3. Pile Drilling Records: Verify and record a pile drilling record for each pile including all of the following items:

    a. Date of drilling.
    b. Pile location.
    c. Drilling equipment and identifying number.
    d. Drilling times.
    e. Initial length of pile.
    f. Pile top elevation; required actual.
    g. Pile cut-off elevation; required/actual.
    h. Final pile length.
    i. Verification and record of Contractor's survey of heave and back drilling.

j. Verification and record of Contractor's survey of final pile location and vertical alignment.
k. Computed capacity of pile.

4. Grouting of Piles: Inspect and test the installation of grout for piles as follows:

a. Visual Inspection: Perform full-time visual inspection of all concrete and reinforcing placement work.
b. Compression Tests: ASTM C31, sampled at point of deposit. Make one set of three cylinders for each three piles cast and/or at least one set for each day's pour. Test one cylinder at the age of seven days. Test two cylinders at the age of twenty-eight days. Take one additional cylinder per day and break at fifty-six days.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The Work of DRILLED MICROPILES shall not be measured for payment.

4.02 PAYMENT

A. No separate payment shall be made for the Work covered in this Section. Payment for the Work of DRILLED MICROPILES shall be included in the Contract lump sum price as shown in the Schedule of Prices for STRUCTURAL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

A. Structural work.

END OF SECTION

SECTION 31 64 00

CAISSONS / DRILLED PIERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Scope: Provide services, labor, materials, tools, and equipment necessary for caissons and testing of caissons. The work includes, but is not limited to the following:

1. Excavation, including removal of existing concrete slabs, foundations, and other obstructions, as required.
2. Layout of foundation locations.
3. Dewatering.
4. Corrugated steel liners.
5. Steel plate casings.
6. Thin shell steel casing at bottom of rock caissons.
7. Reinforcing steel, including caisson reinforcement extending above top of shaft.
8. Concrete.
9. Grouting of annular void around liner.
10. Disposal of excavated materials.

B. Related Work:

1. Section 02 16 10 – Monitoring Adjacent Structures during Construction.
2. Section 03 20 00 – Concrete Reinforcement and Embedded Assemblies.
3. Section 03 30 00 – Cast-in-Place Concrete.
4. Section 31 09 13 – Monitoring Track Structures During Construction.
5. Section 31 15 00 – Shoring.

C. Definitions:

1. Definition of project terms and abbreviations are found within Specification Section 01 35 00.

D. See Drawings for locations, sizes, top elevations, and details. See Drawing entitled "General Notes" for bearing stratum criteria. See geotechnical investigation report for general soil composition.

1.03 REFERENCES

A. Acronyms for reference standards are defined in Section 01 42 00.

B. ACI 318 – Building Code Requirements for Structural Concrete.

C. ACI 336.1 – Reference Specification for the Construction of Drilled Piers and Commentary.

D. ASTM A36 – Standard Specification for Carbon Structural Steel.

E. ASTM A283 – Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.

F. ASTM A929 – Standard Specification for Steel Sheet, Metallic-Coated by the Hot-Dip Process for Corrugated Steel Pipe.

G. ASTM C31 – Standard Practice for Making and Curing Concrete Test Specimens in the Field.

H. ASTM C33 – Standard Specification for Concrete Aggregates.

I. ASTM C39 – Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

J. ASTM C 42 – Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.

K. ASTM C88 – Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.

L. ASTM C143 – Standard Test Method for Slump of Hydraulic Cement Concrete.

M. AWS D1.1 – Structural Welding Code-Steel.

N. IDOT Standard Specifications and Bridge Special Provisions GBSP86, Section 516.

1.04 QUALITY ASSURANCE

A. Caisson Installer: Provide evidence of a minimum of 5 years experience in installing caissons as specified in the IDOT Standard Specifications and Bridge Special Provisions GBSP86 Section 516.04 (a). Provide evidence of successfully completing three previous projects of scope, soils conditions, shaft diameters, and depths similar to this project.

B. Contractor's Field Supervisor: Provide full-time supervision by an experienced caisson construction supervisor with minimum of 10 years experience in installing caissons.

C. Contractor's Professional Surveyor: Retain a Professional Surveyor with 5 years of previous experience in laying out foundation locations to perform surveys, layouts,

and measurements for caisson work. Conduct layout work for each caisson to lines and levels required before excavation, and actual measurements of each caisson's horizontal axial location, shaft diameter, bottom and top elevations, deviations from specified tolerances, and other data as required.

D. Contractor's Geotechnical Consultant: Employ or retain services of a qualified geotechnical consultant, as the Contractor's SSE, to develop a site dewatering plan as required, and advise on caisson construction techniques, including the development of construction procedures and the development of solutions to construction problems.

E. Contractor's Testing Agent: Retain services of a qualified testing laboratory to develop concrete mix designs, conduct trial batches, perform trial-batch tests, and submit reports.

F. Caisson Construction Methods: Submit for record only, caisson construction procedures developed by Contractor's geotechnical consultant. Address minimum requirements outlined in this specification, section entitled: "CAISSON INSTALLATION." Address additional requirements as necessary to provide sound, solid caissons that meet dimensional and other requirements of the Project.

G. Provide caisson with no concrete discontinuity and no void measuring more than 1 in. in any direction.

1.05 SUBMITTALS

A. Submit the following according to Conditions of the Construction Contract and Division 1 Specification Sections.

B. Certification to Examination of Site and Records: Before proceeding with work, submit certification in acceptable form signed by Contractor, stating that careful examination has been made of site, existing structures, records of utility lines, test boring records, soil samples, geotechnical investigation reports, drawings, and Specifications.

C. Product Data: Submit copies of manufacturers' specifications, test results, and certifications for following products, including copies of laboratory test reports and other data as may be required to show compliance with these Specifications.

1. Portland cement.
2. Fly ash.
3. Admixtures.
4. Aggregate sieve analysis.
5. ASTM C88.

D. Mill Certificates: Submit certified reports for physical and chemical properties of following materials:

1. Reinforcing bars.
2. Permanent steel liners.

E. Shop Drawings: Submit shop drawings for permanent steel liners. Retain or employ a qualified, licensed SSE to design corrugated steel liners. Provide calculations sealed by the SSE, licensed in the state in which the project is located.

F. Contractor's Geotechnical Report: Provide reports prepared and sealed by a qualified, licensed professional engineer, addressing any additional geotechnical investigation required by the Contractor, describing the planned construction methods, discussing potential problems, and outlining planned methods of addressing potential problems.

G. Contractor's Material Testing Reports: Provide sealed reports prepared by a qualified, licensed professional engineer. Submit reports addressing proposed concrete mix design, trial batching test results, reports of ASTM C88.

H. Construction Log: Contractor's SSE (geotechnical engineer) shall document, sign, and submit a record of each caisson construction, including caisson designation, top and bottom elevation, size; length and location of permanent liner and casing; length, size, and location of installed reinforcement; deviation of centerline from vertical, levelness of caisson base, seepage of water, inspection, testing; and method of concrete placement, time of beginning and ending concrete discharge for each truck, (including any delays in concreting and location of construction joints in shafts) and any deviation from planned construction methods.

I. Contractor's Survey Report: Provide reports prepared and sealed by Contractor's licensed professional surveyor, indicating plan locations of caisson centerlines and identifying deviations of caisson centerlines from design plan locations.

J. Installation Procedure: Forty-five days prior to beginning caisson construction, the Contractor shall submit the proposed procedure for the installation of all caissons on the project to the Commissioner. The Contractor's procedures shall always be subject to the Commissioner's approval. The contractor's process plan shall at a minimum include the following:

1. Permanent, temporary casing and liner design calculations signed and sealed by Contractor's SSE, if used.
2. Detailed installation procedure:

    a. Equipment List: List of proposed equipment to be used including cranes, drill rigs, augers, belling tools, casings, vibratory hammers, core barrels, bailing buckets, final cleaning equipment, slurry equipment, tremies, or concrete pumps, etc., and load charts.
    b. General Sequence: Details of the overall construction operation sequence, equipment access, and the sequence of individual caisson construction within each bent, footing group, or the caisson construction is within the Zone-of-Influence of adjacent spread footing or shoring towers. The submittal shall address the Contractor's proposed time delay and/or the minimum concrete strength necessary, or measures taken to protect adjacent spread footing or shoring towers before initiating a caisson excavation.
    c. Caisson Excavation: A site-specific step-by-step description of how the Contractor anticipates the caisson excavation to be advanced based on their evaluation of the subsurface data and conditions expected to be

encountered. This sequence shall note the method of casing advancement, anticipated casing lengths, tip elevations and diameters, the excavation tools used, and drilled diameters created. The Contractor shall indicate whether wet or dry drilling conditions are expected and if groundwater will be sealed from the excavation.

d. Slurry: Only dry polymer slurry is an acceptable submittal option. Submittal product data shall be proposed by the Contractor and approved by the Commissioner. In addition, details covering the measurement and control of the hardness of the mixing water, agitation, circulation, desanding, sampling, testing, and chemical properties of the slurry shall be submitted.
e. Caisson Cleaning: Methods and sequence proposed for the caisson cleaning operation.
f. Reinforcement Cage and Permanent Casing: Details of reinforcement placement including rolling spacers to be used and method to maintain proper elevation and location of the reinforcement cage within the caisson excavation during concrete placement. The methods of adjusting the reinforcement cage length and permanent casing if rock is encountered at an elevation other than as shown on the Contract Document or rock core investigation for the City of Chicago Department of Building Deep Foundation Review.
g. Concrete Placement: Details of concrete placement including proposed operational procedures for free fall, tremie, or pumping methods. The sequence and method of temporary casing grouting and removal shall also be stated along with the top of pour elevation.
h. Slurry Disposal Plan: Containment and disposal plan for slurry and displaced water. Containment and disposal plan, approved by the Commissioner, for contaminated concrete pushed out of the top of caisson by uncontaminated concrete during concrete placement.

3. Access and Site Protection Plan: Details of access to the caissons and safety measures proposed. This shall include a list of casing, scaffolding, work platforms, temporary walkways, railings, and other items needed to provide safe access to the caissons. Provisions to protect open excavation during nonworking hours shall be included if permitted by the Commissioner
4. A letter from the Contractor's SSE confirming that they agree with construction methods of the proposed methods and installation plan submitted.
5. Details and diagrams of lifting reinforcement cages, and additional bracing bars as stiffeners at the lifting point to prevent local damages to the cages as necessary.

K. Caisson construction and inspection checklist to be used.

1. When the use of slurry is proposed and approved by the Commissioner, provide independent testing lab testing procedures for the full-depth concrete core destructive testing and repair methods, procedures for Nondestructive Testing of Thermal Integrity Profiling (TIP), and procedures to measure and monitor the volume of concrete placed with the height of the concrete in the caisson.
2. Contractor's Caisson Tolerance Report: The Contractor shall submit a caisson report for each caisson to the Commissioner showing that the construction tolerances as indicated in these Specifications have been met.

1.02 PROJECT SITE CONDITIONS

A. Geotechnical Information: Examine site, records of test borings, soil samples, and geotechnical investigation report, that are available from the Commissioner. Soil boring test results are provided by the Commissioner for information and are not guaranteed to represent conditions that are present at caisson locations. Soil boring test results are not intended as representations or warranties of the continuity of the reported conditions. It is expressly understood that the Commissioner will not be responsible for interpretation or conclusions drawn by Contractor from the geotechnical investigation report. At no additional cost to the Commissioner, evaluate the available data and provide additional test borings and other investigations as necessary for installing caissons.

B. Site Survey: Survey of site, existing utilities, and existing construction available from the Commissioner represent conditions known to Commissioner. Other obstructions may be encountered.

1.03 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Commissioner’s preferred location.

B. Retain subparagraph below if additional requirements are necessary; include information about conference.

1. Review methods and procedures related to caissons including, but not limited to, the following:

a. Review geotechnical report.
b. Discuss existing utilities and subsurface conditions.
c. Review coordination with temporary controls and protections.
d. Review measurement and payment of unit prices.

PART 2 - PRODUCTS

2.01 PERMANENT CORRUGATED STEEL LINER

A. ASTM A929, sheet steel, zinc coated. Design corrugated steel liners to withstand handling stresses, construction loads, and pressures induced by hydrostatic head, concrete placement, soil, and other forces, as applicable. Provide manufacturer's standard finish. Limit out of roundness to 2% of diameter. Design for the indicated tolerances. Design with a 1.5 safety factor against buckling.

B. Install permanent corrugated steel liners inside of temporary casings to form the caisson shaft before the concrete pour. Remove and replace, or repair liners, which are damaged during installation and which could impair the strength or efficiency of the completed caisson.

1.06 TEMPORARY STEEL PLATE CASING

A. ASTM A252 Grade 2, produced by electric seam, butt, or spiral welding. Temporary casings shall be provided to prevent cave-ins and displacement of earth, and for keeping silt and water out of the caisson excavation. This casing shall extend from the height of 1 ft-0 in. (one foot) above grade, through the miscellaneous fill, into the strata of clay. Where necessary, the inside diameter of the casing shall be large enough to permit installation of a permanent corrugated liner inside of the temporary casing.

C. All excavation required to install the temporary casing through any water bearing soils shall be performed under a slurry head sufficient to prevent caving. All excavation shall be supported by the slurry until the temporary casing has been installed with a minimum 10 ft-0 in. (ten foot) seal into the clay strata. The casing should be pushed or twisted to a depth sufficient to prevent soft clay squeeze.

D. Design casing to withstand handling stresses, construction loads, and pressures induced by hydrostatic head, concrete placement, soil, and other forces as applicable. Limit out of roundness to 2% of diameter. Design for the indicated tolerances. Design with a 1.5 safety factor against buckling.

2.02 PERMANENT THIN-SHELL STEEL PLATE CASING

A. ASTM A283, Grade C; or ASTM A 36, all vertical joints provided with full penetration welds, per AWS D1.1. Design casing to withstand handling stresses, construction loads, and pressures induced by hydrostatic head, concrete placement, soil, and other forces as applicable. Limit out of roundness to 2% of diameter. Design for the indicated tolerances. Design with a 1.5 safety factor against buckling. Provide a minimum thickness of 3/8 in.

2.03 CONCRETE

A. See Specification section 03 30 00 Cast-In-Place Concrete and additional requirements listed below.

B. Retarder: Sufficient to prevent temporary set for a period of 4 hrs from completion of batching.

C. Concrete Placed by Tremie Method: Include coarse aggregates with maximum size conforming to Size 7 per ASTM C 33 and a minimum cement content of 8 sacks/cu yd.

D. For concrete placed in a dry open hole, provide slump of 4 in. to 6 in. For concrete placed by tremie method, provide slump of 7 in. to 9 in.

E. Controlled Slurry: Stable colloidal suspension of dry polymers thoroughly mixed with water and in compliance with ACI 336.1.

F. Fly Ash: Limit use of fly ash to 25% of weight of Portland cement.

G. When the use of slurry is proposed and approved by the Commissioner, cementitious content for the caisson concrete mix shall be no less than 600 lbs per cubic yard; and concrete delivered for placement shall ensure to have a slump at the upper limit of the allowable slump range.

2.04 LEAN GROUT

A. Provide grout with minimum cube strength of 1,000 psi at twenty-eight days.

2.05 REINFORCEMENT

A. Shall conform to the requirements of Section 03 20 00 Concrete Reinforcement and Embedded Assemblies and as modified herein.

B. For compression caissons without rock socket, in the event of over drill, the bottom of the reinforcement shall be no more than one caisson diameter of the caisson above the bottom of the caisson, but no more than 3 ft in any case.

2.06 SLURRY

A. Slurry shall be dry polymer type, and shall be approved by the Commissioner.

B. The physical properties of the dry polymer type slurry shall be as shown below:

1. Density (at introduction): 63 lb/cu ft max. Test Method: ASTM D4380.
2. Density (prior to concrete placement): 63 lb/cu ft max. Test Method: ASTM D4380.
3. Viscosity: 65 +/- 15 sec/qt. Test Method: ASTM D6910.

    a. Higher viscosities may be required in loose or gravelly sand deposits.

4. pH: 9.0 +/- 2.0. Test Method: ASTM D4972.
5. Sand Content (at introduction), 1 percent by volume max. Test Method: ASTM D4381.
6. Sand Content (prior to concrete placement), 1% by volume max. Test Method: ASTM D4381.
7. Contact Time: 72 hrs max.

    a. Contact time is the time without agitation and sidewall cleaning.

PART 3 EXECUTION

3.01 PROTECTION OF EXISTING UTILITIES AND STRUCTURES

A. Before installing caissons adjacent to known existing utilities, notify utility owner to ensure that protective work will be coordinated and performed by Contractor in accordance with requirements of the owner of utility or building. If any existing

service lines, utilities, and utility structures to remain in service are uncovered, or encountered during work, protect the uncovered element from damage and provide support where necessary.

B. Should uncharted or incorrectly charted piping or other utilities be encountered during caisson drilling operations, immediately notify Commissioner and utility owner. Cooperate with Commissioner and utility owner in keeping their respective services, utilities, and facilities in operation. Repair damaged utilities to entire satisfaction of Commissioner and utility owner concerned.

C. Do not interrupt existing utility service facilities occupied and used by Commissioner and others, except when permitted in writing by Architect/Engineer and then only after acceptable temporary utility services have been provided.

D. Protect structures, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, vibration, and other hazards created by caisson operations.

3.02 SITE DEWATERING

A. Before installing caissons, provide a site dewatering plan as required by the Contractor's geotechnical consultant, to lower water table at the site to the top of rock, designated as the bearing stratum for the straight-shaft caissons. If dewatering is not required, obtain written verification from the Geotechnical Engineer. If a dewatering plan is required, ensure the following is performed in addition to the Geotechnical Engineer’s requirements:

1. Before installing caissons, provide site dewatering based on the Contractor’s site dewatering plan. Provide dewatering at a minimum of two augured locations, using a double-tank-filtered system.
2. Provide and maintain pumping equipment to keep excavations free of water before placing concrete. If excessive water is encountered and drilling operations must be halted, consult the Engineer before using alternate methods of construction.
3. If excessive seepage is coming in from below the bottom, removal by pumping is inappropriate, as this may loosen the bearing soils and reduce the bearing soil capacity; therefore, an alternate means of construction will be required.

3.03 GENERAL CAISSON EXCAVATION

A. Tolerances: For caisson shaft diameters less than or equal to 60 in., place caisson centerline within 2 in. of shaft centerline location, as indicated on Structural Drawings. For caisson shaft diameters greater than 60 in., place caisson centerline at a distance no greater than 5% of shaft diameter from the shaft centerline location indicated on Structural Drawings. Provide caisson centerline with a local slope of no more than 1/10 in. per foot at any point, and an overall slope of no more than 1/10 in. per foot or 3 in., whichever is smaller. The center of the reinforcement cage shall be within 1 in. of the plan station or location and offset at the top of the shaft. The out of vertical plumbness of the shaft reinforcement cage shall not exceed 0.5% of the caisson length or 1-1/2 in., whichever is the smaller value. The top of shaft shall be

no more than 1 in. above and no more than 3 in. below the plan elevation. The top of the reinforcement cage shall be no more than 1 in. above and no more than 3 in. below the plan elevation. Excavation equipment and methods used to complete the caisson excavation shall have a nearly planar bottom. The cutting edges of excavation equipment used to create the bottom of caissons in rock shall be normal to the vertical axis of the caisson within a tolerance of 6.25%. If indicated tolerances are exceeded, design and furnish additional calculations or corrective construction, to compensate for eccentricity in excess of these values, at no extra cost to Commissioner. Provide calculations performed and sealed by a licensed Structural engineer.

B. Concrete Cut-off Elevation: plus 1 in., minus 3 in.

C. Cleanup of Caisson Bottom: Do not enter excavation. Perform observations using remote cameras. Oversizing of bell by 15% beyond the size indicated on the Drawings may be used at Contractor's option instead of the remote camera observation. Remove loose materials or free water as determined by the Commissioner. Excavate bottom to a level plane. If bottom is sloped rock, excavate to a level plane or step with maximum step height less than one-quarter the diameter of the bearing area.

D. Equipment: Use equipment of adequate capacity and proven methods.

E. Loss of Soils: Minimize loss of soils due to pumping. Minimize squeezing of excavation. Limit loss of ground and subsequent settlement to least possible amount by limiting annular spaces beyond permanent liners to specified values, performing excavation under slurry if needed, grouting annular spaces beyond permanent liners, and limiting soil quantity pumped out.

F. Excavate holes for caissons to the required bearing strata as determined by the Commissioner. Excavate holes for closely spaced caissons, and those occurring in fragile or sand strata, only after adjacent holes are filled with concrete and allowed to set.

3.04 ADDITIONAL EXCAVATION AND CAISSON LENGTH

A. Do not excavate below elevations noted by the Project Documents without prior review and approval by the Commissioner. No payment will be made for extra length when caisson shafts are excavated to a greater depth than indicated on drawings, due to over-drilling by Contractor. In the event of an overexcavated shaft, complete caisson and fill extra depth with concrete, if other conditions are satisfactory. Overexcavated shafts will be measured and paid for to original design or authorized depth.

B. Where Contractor's geotechnical engineer determines that soil encountered at an elevation is not capable of supporting design load, perform additional excavation, as reviewed by Contractor's geotechnical consultant. Alternatively, caisson bells as shown in the structural drawings may be increased in diameter by up to 1 ft to reduce bearing pressure below caisson bell.

C. If obstructions are encountered that interfere with new construction, remove such existing elements or develop corrective methods and submit for review by the

Commissioner. Removal of any such obstructions shall be performed at no additional cost to the Commissioner.

3.05 DISPOSAL OF EXCAVATED MATERIALS

A. Dispose excavated materials off site in a manner that will not interfere with other construction activities. Continuously keep construction site clean and free of soil and other debris that could affect progress of other construction activities.

3.06 CAISSON INSTALLATION

A. Develop construction methods by selecting one or more of the methods indicated in this Section and meeting the listed minimum requirements.

B. Belled Caisson, with Temporary Steel Plate Casing, and with Permanent Corrugated Liner.

1. Use machine methods for excavation of shafts and bells. Provide temporary steel plate casing as indicated by the drawings and at additional locations as necessary to prevent caving of soil and limit water seepage. Install permanent corrugated steel liners as indicated by the drawings. Diameter of hole shall not exceed outside diameter of permanent corrugated liner by more than 12 in. Grout annular space outside the permanent corrugated liner using lean grout.
2. Temporary steel plate casings may be left in place or removed at the option of the Contractor. If a steel plate casing is left in place, grout any void outside the casing.
3. If temporary casing located above stiff clay is removed, withdraw casing no earlier than 12 hrs after completion of caisson concrete placement. Withdraw temporary casing as grouting of the annular space outside the permanent corrugated liner is performed. Maintain a grout head 5 ft above casing bottom.
4. If temporary casing located in stiff clay is removed, withdraw casing as shaft is filled with concrete. Prior to beginning casing withdrawal, attain a concrete head of 3 ft above hydrostatic head. Alternatively, maintain concrete head at 5 ft above bottom of casing at all times during the withdrawal. For any delivery truck depositing against temporary casing, limit time lapsed between cement entering the mixing drum and removal of temporary casing to 2.5 hrs. Withdraw temporary casing with a smooth, vertical motion, without jerking. Provide adequate reinforcement support to avoid motion of reinforcement.
5. If for any reason, complete withdrawal of casing is not accomplished within the allotted period of time, then leave steel plate casing where it is and cut off casing at proper top elevation. Any cutting and complete or partial loss of casing shall be at expense of the Contractor.
6. Testing: At 100% of locations where a casing that is partially or completely installed in stiff clay is partially or completely withdrawn, Testing Agency will perform nondestructive testing as necessary to detect any discontinuity within the depth of caisson, above the lowest elevation of casing bottom. Where necessary for verification, as determined by the testing agency, the Contractor will provide coring for three 4 in. diameter core-drilled samples. Testing Agency will examine core-drilled samples and will submit report of visual examination.

7. Once the excavation has started for any caisson, the work of that caisson shall be carried on continuously, 24 hrs a day, including Saturdays, Sundays, and Holidays, until the caisson has been completed all at no additional cost to the Commissioner. If at any time, work on any caisson is not continuous for any reason not approved by the Commissioner, any and all casings which have been installed in the caisson for any reason shall be left in place and back grouted immediately at the Contractor's expense

3.07 CAISSON BEARING STRATA

A. Belled Caisson Bearing Stratum Criteria and Verification:

1. Belled caissons shall be founded on soil strata with bearing capacity indicated on Drawings. Caisson bells shall not be excavated until test results by Contractor's geotechnical consultant confirm allowable bearing values indicated on Drawings but shall be excavated immediately thereafter. In no case shall bottom of belled caisson be excavated deeper than a depth that may produce a bottom blowout due to high underlying hydrostatic pressure. If test results indicate that soil is incapable of providing required safe-bearing values, advance shaft length as reviewed by the Commissioner or bells may be enlarged as reviewed and approved by the Commissioner.
2. Each caisson bearing strata must be inspected and be acceptable to the Commissioner before placing concrete.

3.08 BELLED CAISSON CORRECTIVE METHODS

A. If water conditions are found that makes excavation through sand or silt strata dangerous to personnel or such as to cause excessive inflow of silt or sand creating voids outside caissons, develop corrective methods and submit for review and action by Architect/Engineer. For excavation of bell, where appropriate, optionally use "oversized grout bell technique," described in the geotechnical investigation report.

B. If concrete placement is suspended before completion of caisson or a construction joint is required for some other reason, indicate location on field record drawings. Remove debris and laitence from joint before placing additional concrete and create a construction joint as detailed on Drawings.

C. If caissons are installed outside allowable tolerances, develop corrective methods and provide calculations based on actual locations of caissons, taking into account eccentricity between final centerline of caisson and design location of column centerline. Provide calculations performed and sealed by a Structural Engineer, licensed in the state where the project is located.

3.09 PLACING CONCRETE IN DRY HOLE

A. Place concrete in dry hole unless specifically reviewed by Commissioner.

B. Place concrete only after excavation of caisson and securing of reinforcement are completed and bottom is cleaned, and after inspections by testing agency are completed.

C. Place concrete in belled caisson within 8 hrs of exposing bearing stratum. Place concrete only after receipt of verification of bearing stratum.

D. Provide adequate top hoppers with chutes, for conveying concrete into place. Place concrete sufficiently above caisson wall or reinforcement, such that wall or reinforcement is not in contact with chutes.

E. Place concrete immediately after mixing, and in no case more than 90 min. after initial mixing. Continue depositing concrete until completion of caisson to top of shaft. Install construction joint as detailed on drawings if placement of concrete is suspended for more than 60 min. Remove laitence and excess water from top of completed caisson. Do not allow concrete to hit sides of shaft or reinforcing cage during placement.

F. Place concrete for belled caissons only after receiving approval from the testing agency, based on an evaluation of water inflow, where applicable.

3.010 PLACING CONCRETE UNDER TREMIE METHOD

A. Tremied concrete shall be placed in accordance with Articles 503.07 and 503.08 of the IDOT Standard Specifications, except as modified herein.

B. The bottom of the tremie shall extend to within a foot of the bottom of the excavation. The tremie shall be withdrawn as the concrete is placed, but the bottom of the tremie shall always be at least 2 ft below the top of the concrete. The method of placing the concrete shall be subject to the approval of the Commissioner at all times, and the method used shall be one that provides a continuous flow with no segregation of the concrete materials.

C. Wherever tremie concrete is necessary, casing shall not be removed. Once placing of the concrete has started, no pumping of any kind shall be allowed.

3.011 FIELD QUALITY CONTROL

A. Contractor's Responsibilities:

1. Examine the areas and conditions under which caissons are to be installed. Notify the Commissioner in writing of conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in an acceptable manner.
2. Furnish complete sets of processed shop drawings and other submittals to the Commissioner and Contractor's testing agency and SSE (geotechnical engineer).
3. Furnish notifications to the Commissioner and Contractor's testing agency and SSE (geotechnical engineer), with at least 24 hr advance notice of start of drilling each caisson.

4. Provide access for the Commissioner and Contractor's testing agency and SSE (geotechnical engineer). Provide concrete materials for sampling and testing.
5. Furnish storage facilities for material samples, in accordance with ACI Standard Practice.
6. Provide additional inspection and testing resulting as a consequence of following:

    a. Lack of adequate evidence that work is compliance with this Specification.
    b. Work performed with improper supervision.
    c. Work performed without prior notice.
    d. Work performed contrary to Drawings and Specifications.

B. Testing Agency: Perform tests and inspections, as specified herein, evaluate test results, and review compliance of installed work with Contract Documents.

1. Review Contractor's proposed caisson installation methods, sequences, procedures, and equipment.
2. Visually inspect fabrication of permanent steel plate casings and steel liners, verify welder AWS certifications, and perform ultrasonic testing, per AWS D1.1, of 100% of welds.
3. Verify bearing stratum of each caisson.
4. Determine final bearing elevation at each caisson location and possible need for additional shaft excavation.
5. Visually inspect and test samples of water being pumped from caisson to determine solids content.
6. Observe, record, and report Contractor's location and plumb tolerance measurements, and final elevations of bottom and top of completed caissons. Record and report elevations of top and final bottom of rock excavation.
7. On a full-time basis, visually inspect installation of each caisson, including verification of bearing stratum, extent of cleanup, placement of concrete, removal of temporary casings. Evaluate and note any actions that may allow soil inclusion in caisson or may affect integrity of the completed caisson.
8. Inspection of Concrete and Reinforcement Placement: Provide continuous visual inspection of site fabrication and installation, of reinforcement and concrete placement including verification of laitance removal at top of caissons and at construction joints.
9. Compression Tests: Perform one set of tests for each 50 cu yd. of concrete, or fraction thereof, but not less than one set of cylinders for each caisson. Make four standard cylinders and test in accordance with ASTM C31 and C39. Test one cylinder at age of seven days and two cylinders at age of twenty-eight days. Keep one cylinder in reserve for fifty-six-day test if twenty-eight-day test does not meet requirements. Only one set of tests shall be made from any one batch of concrete and all four cylinders shall be made from same batch. Additionally, one cylinder for seven-day test shall be taken from every truckload. Cure cylinders to simulate same curing conditions as concrete used in caissons. Reports of cylinder tests shall state location of concrete placed in caisson, laboratory or site curing, compression strength, type of fracture, age at testing, concrete supplier, mix specification strength, any other pertinent information, test results, and conclusions.
10. Slump Tests: ASTMC 143. Make one test from each truck.

11. Inspection of Batch Plant: As required to ensure that concrete delivered to job complies with specifications and design mix. Batch plant inspection shall be required once at start of job and thereafter if concrete falls below specifications.
12. Additional Tests: Perform additional testing if, in opinion of Architect/Engineer, based on cylinder strengths below specification requirements or visual defects, concrete of poor quality has been placed. Tests may be compression tests on cored cylinders, ASTMC 42, and load tests as outlined in ACI 318, or as directed by Architect/Engineer. Complete continuous coring of caissons will be required, at Contractor's expense, where verification of quality of concrete is not otherwise attainable.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The work of CAISSONS / DRILLED PIERS shall not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this Section. Payment for the Work of CAISSONS / DRILLED PIERS shall be included in the Contract lump sum price as shown in the Schedule for Prices for STRUCTURAL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

A. Structural Work: 03 00 00.

END OF SECTION

SECTION 32 11 16

SUB-BASE GRANULAR MATERIAL, TYPE B

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section specifies requirements for SUB-BASE GRANULAR MATERIAL, TYPE B. The work under this Section will include furnishing all labor, materials, tools, and equipment required to furnish, place and compact sub-base granular material, Type B on a prepared subgrade.

B. Except as modified herein, the work will conform to the applicable portions of the Standard Specifications (IDOT), Section 311, at locations shown on the Drawings and as directed by the Commissioner.

C. Related Sections:

1. Section 312313: Subgrade Preparation.
2. Section 321621: Concrete Curbs, Gutters and Walks.
3. Section 321313: Concrete Pavement
4. Section 321623: Portland Cement Concrete Sidewalk 5 inch
5. Section 321623.10: Portland Cement Concrete Sidewalk Special

1.03 REFERENCES

A. Illinois Department of Transportation (IDOT) Standard Specifications for Road and Bridge Construction, Adopted April 1, 2016 or latest edition.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS:

A. The material must be coarse aggregate having a CA-6 gradation conforming to Article 1004 of the Standard Specifications except as herein modified.

PART 3 - EXECUTION

3.01 SUB-BASE GRANULAR MATERIAL

A. It is understood that a certain amount of sub-base granular material, may be displaced into the existing soil when the material is placed and compacted; however, any such material will not be measured for payment and the cost thereof considered incidental to this item Conform to IDOT Standard Specifications for Road and Bridge Construction.

B. The sub-base granular material must not be placed on a wet subgrade or a subgrade rutted by the Contractors equipment. The Contractor will be required to drain off all rainfall as rapidly as possible and maintain the subgrade in a dry, smooth, and compacted condition until the granular material is placed.

C. The sub-base granular material must be placed and compacted according to Article 311.05 of the Standard Specifications.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The Work of SUB-BASE GRANULAR MATERIAL, TYPE B will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the Work of SUB-BASE GRANULAR MATERIAL, TYPE B will be included in the contract lump sum price as shown in the Schedule of Prices for CIVIL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 020000

END OF SECTION 32 11 16

SECTION 32 12 16

ASPHALT PAVEMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes requirements for Hot Mix Asphalt (HMA) Pavements as required for proposed roadway binder and surface courses proposed with the project improvements.

1.03 RELATED SECTIONS

A. Section 015526 – Traffic Control.

B. Section 321313 – Concrete Pavement

C. Appendix B – CDOT Special Provisions

1.04 REFERENCES *

A. CDOT Regulations for Openings, Construction, and Repair in the Public Way (CDOT Specifications), July 2012.

B. IDOT Standard Specifications for Road and Bridge Construction (SSRBC), latest edition.

*In the event of a conflict between CDOT and IDOT Specifications in this Section, CDOT Specifications shall govern.

1.05 MATERIAL TESTING, INSPECTIONS, AND SUBMITTALS

A. All materials and workmanship are subject to inspections, testing, and approval by the Commissioner.

B. Unless otherwise designated by the Commissioner, all tests must be conducted to current CDOT standards.

C. Provide 100% quality control (QC) independent of said contractor for all field testing in accordance with CDOT and IDOT Standards. The contractor is responsible for notifying CDOT Commissioner no later than 2pm on the day previous to the asphalt placement. All provisions required for tests, samples and inspections are considered incidental to the Work and no additional payment is allowed.

D. Failure of the Contractor to pass required tests and inspections is grounds for rejection of the Work. All rejected Work is subject to removal or other corrective actions as directed by the Commissioner.

1.06 QUALITY ASSURANCE

A. Comply with CDOT Specifications for all work within public right-of-way and IDOT Article 1030.05 for QC/QA. In the event that a conflict exists between this Section and the CDOT Specifications, CDOT Specifications govern. Work, which is not within CDOT jurisdiction, must be coordinated with the agency having jurisdiction to ensure compliance with applicable standards and permit requirements. The Contractor is responsible for forwarding copies of correspondence to the Commissioner for proof of coordination and compliance with CDOT and other agency regulations.

B. Material Tickets

1. Deliver to the Commissioner, at the time of delivery, a weight ticket for all material delivered signed by a Certified Public Weighmaster indicating the net weight or volume and mix or type of material being delivered.

PART 2 - PRODUCTS

2.01 AGGREGATE

A. Aggregate materials must be coarse aggregate consisting of mechanically crushed stone or mechanically crushed concrete, and must meet the requirements of Section 1004 of the SSRBC. Material must have a pH range between 7.5 and 10 and be non-corrosive.

The material shall be according to Section 1004.04 of the Standard Specifications except for the following:

Reclaimed Asphalt Pavement (RAP) may be blended with gravel, crushed gravel, crushed stone, crushed concrete, or crushed sand stone. The RAP materials shall be crushed and screened. Unprocessed RAP grindings will not be permitted. The RAP shall be uniformly graded and shall pass the 1.0 in. (25 mm) screen. When RAP is blended with any of the coarse aggregate listed above, the blending shall be done mechanically with calibrated feeders. The feeders shall have an accuracy of + 2.0 percent of the actual quantity of material delivered. The final blended product shall not contain more than 40 percent by weight RAP.

B. Gradation of aggregates.

1. Aggregate for Sub-Base Course-Type B, Aggregate Base Course, and Temporary Stone Fill must be gradation CA-6.
2. Aggregate for Sub-Base Course-Type A must be gradation CA-6.

2.02 HOT MIX ASPHALT

A. Hot Mix Asphalt (HMA), Reclaimed Asphalt Pavement (RAP) (D-1), and Reclaimed Asphalt Shingles (RAS) (D-1) mix selections are to conform to mixes as described in the latest CDOT and IDOT requirements as noted on the drawings, or as directed by the Commissioner.

B. HMA materials are to conform to Section 406, 1030, and 1031 of the SSRBC.

C. HMA base course must conform to the requirements of Section 355 of the SSRBC.

D. Gradation: The fine aggregate gradation for all HMA shall be FA1, FA 2, FA 20, FA 21 or FA 22. When Reclaimed Asphalt Pavement (RAP) is incorporated in the HMA design, the use of FA 21 Gradation will not be permitted.

2.03 PRIME AND TACK COATS

A. Bituminous material for prime and tack coat must conform to the requirements of Section 1032 of the SSRBC concerning Liquid Asphalt.

1. Prime coat material for application over aggregate base courses must be Grade MC30.
2. Tack coat for application over concrete or bituminous base courses must be Grade SS-1, unless directed otherwise by the Commissioner.
3. Aggregate materials for prime or tack coats for streets open to traffic must be limestone or granite screenings free from dust and conforming to the requirements of Section 1003.03 of the SSRBC. Aggregate materials for tack coat must be gradation FA-1, FA-2 or FA-3.

2.04 REFLECTIVE CRACK CONTROL TREATMENT

A. Reflective crack control materials must conform to the requirements of Section 443 of the SSRBC for System A.

PART 3 - EXECUTION

3.01 GENERAL

A. If the limits of excavation of the trench width and/or the edge of the cut lines are exceeded during excavation, the restoration limits must be extended to include the additional widths.

B. In order to assure a straight-line edge restoration, the Commissioner may extend the width of the pavement removal and restoration to the extent that may be deemed necessary to satisfy the intent of this Section.

C. Plating of Unattended Excavations

1. All unattended openings in streets, alleys, and driveways necessitated by the work under this contract, must be covered with steel plates of adequate thickness to provide protection to both vehicular and/or pedestrian traffic.
2. Steel plate(s) subjected to vehicular traffic must be of a sufficient thickness to support AASHTO HS-20 traffic loadings without movement, and be secured to the pavement surface to prevent rocking or movement which could expose the excavation. When steel plates are to be left in place beyond normal working hours and in areas subjected to pedestrian traffic, a bituminous ramp is to be provided around the perimeter of the plate(s), to provide a smooth transition between surface of the plate(s) and the surrounding pavement, unless directed otherwise by the Commissioner.
3. Plating of openings is not intended as a substitution for providing traffic control, which must be provided in accordance with Section 015526.

3.02 TEMPORARY PAVEMENT

A. Provide temporary pavement where specified and as directed by the Commissioner. Temporary pavements must consist of HMA binder or crushed stone fill, as directed by the Commissioner.

B. In placing and compacting the crushed stone fill, the Contractor must conform to the applicable requirements of Section 351 of the SSRBC, except that the crushed stone surface fill must be compacted to the degree required to maintain the safe passage of vehicular and pedestrian traffic.

C. Maintain the temporary pavement in a passable and safe condition for traffic and surface drainage.

D. Fill sidewalk areas disturbed by construction with compacted crushed stone fill and grade to provide safe passage for pedestrian traffic. The thickness of the compacted crushed stone fill is to be 4-inches, unless otherwise directed by the Commissioner.

E. The Commissioner will be the sole judge as to when compaction densities, required herein, have been obtained.

F. Surface Treatment of Temporary Pavement

1. Apply prime coat to temporary aggregate surface in accordance with the requirements of Section 406.05 of the SSRBC, except as modified herein. Before placing the Bituminous Material Prime Coat, the base must be compacted and cleaned of all dirt and foreign material. The bituminous material for the tack coat must be applied uniformly at the rate of 0.10 to

0.25 gal per sq. yd. The exact rate will be specified by the Commissioner. Bituminous material must not be placed on wet surfaces.

2. Apply ¼-inch thick uniform layer of aggregate screening over the asphalt treated surface.

G. HMA temporary surfacing will be placed only at locations as directed by the Commissioner. Temporary bituminous pavement must not exceed 3-inches in thickness,

unless directed otherwise by the Commissioner.

3.03 SURFACE MILLING

A. Where restoration is shown on the Drawings, is specified, or is directed by the Commissioner, the existing pavement surface is to be removed to a sufficient depth to accommodate resurfacing the pavement with HMA Surface Course, HMA Binder Course and/or Leveling Binder Course, as specified in the pavement restoration note on the drawings, or as directed by the Commissioner. All pavement restoration including but not limited to HMA / final bituminous surface course and permanent pavement markings must be completed within seven (7) days of commencing milling operation.

1. When the vertical differential between the milled pavement surface and adjacent pavement exceeds 2¼-inches, a stepped milled wedge longitudinal joint must be provided. Each step is to be a minimum of 9-inches in width for each 1-inch in differential height.

B. The machine used for surface removal must be a self-propelled milling machine capable of planning and cutting the existing surface and depositing the cuttings into a windrow or loading directly into trucks.

C. The machine must be capable of removing, in one pass, a layer of bituminous or portland cement concrete material of at least 6 feet in width.

D. The machine must be capable of accurately and automatically establishing profile grades by referencing from either the existing pavement, or from an independent grade control to provide a milled surface with a tolerance of 3/16-inch in 10 feet when checked with a 10 feet straight edge.

E. Remove the excess material from the surface without permitting dust from the operation to escape into the air.

F. The temperature at which the Work is performed, the nature, the condition of the equipment, and the manner of performing the Work must be such that the milled surface must not be, gouged, shaved, or otherwise damaged by the milling operation.

G. Make sufficient cutting passes so that all irregularities or high spots are eliminated to the satisfaction of the Commissioner.

H. Remove the pavement to the required depth adjacent to structures such as drainage castings and utility covers using machine or hand methods in a manner satisfactory to the Commissioner.

1. Provide a temporary bituminous ramp around utility structures where directed by the Commissioner.

I. The Contractor is responsible for the disposal of all milled materials off of the Site, unless otherwise directed by the Commissioner.

1. After cold milling a traffic lane, the pavement must be swept by a mechanical broom to prevent re-compaction of the cuttings onto the pavement. All loose material must be removed from the roadway to the satisfaction of the Commissioner. Temporary ramps are to be provided at butt joints between milled and existing pavements on both the approach and departure ends.

J. Removed bituminous and Portland cement concrete materials are to be removed from the site and taken to a recycling facility.

3.04 HOT MIX ASPHALT PAVEMENT

A. Sub-base Preparation

1. Construct sub-base in accordance with the requirements of Section 311 of the SSRBC, to match the existing pavement cross-section, to the lines and grades shown on the Drawings, or as established by the Commissioner.

B. Aggregate Base Course

1. Add water to the material during compaction only when it is necessary to increase the percentage of moisture to obtain the required density.

C. Tack and Prime Coats

1. Apply tack coat to all prepared aggregate base course in accordance with the requirements of Section 406.05(b) (2) of the SSRBC, except as modified herein. Before placing the Bituminous Material Tack Coat, the base must be compacted and cleaned of all dirt and foreign material. The bituminous material for the tack coat must be applied uniformly at the rate of 0.10 to 0.25 gal per sq. yd. The exact rate will be specified by the Commissioner. Bituminous material must not be placed on wet surfaces.
2. Apply prime coat to prepared bituminous or concrete base course in accordance with the requirements of Section 406.05(b) (1) of the SSRBC. Before placing the Bituminous Material Prime Coat, the base must be cleaned of all dust, dirt and foreign material. The bituminous material must be applied uniformly at the rate of 0.05 to 0.10 gal per sq. yd. The exact rate will be specified by the Commissioner. Bituminous material must not be placed on wet surfaces.
3. When the road is to be kept open to traffic, the tack or prime coat (except emulsion type) must be placed not less than 1 hour in advance of the

placement of HMA and no tack or prime coat may be placed more than 5 days in advance of the placement of HMA.

4. When the road is closed to thru traffic, non-Emulsion type prime may be placed no more than 5 days in advance of the placement of HMA.
5. When directed by the Commissioner, the tack or prime coat must be covered immediately following its application with fine aggregate mechanically spread at a uniform rate of 2 to 4 lbs. per sq. yd.
6. "Fresh Oil" signs must be posted at all ingresses to primed surfaces.

D. Bituminous Wearing Course

1. Construct HMA binder course and HMA surface course as noted in the pavement restoration note on the Drawings, and HMA temporary surfacing as directed by the Commissioner, in accordance with the IDOT requirements of Section 406 of the SSRBC.
2. Unless otherwise directed by the Commissioner, where the existing bituminous thickness over a concrete or brick base is less than the combined proposed level binder and surface course thickness, reduce the thickness of the level binder course. If the reduced thickness of the level binder course is less than ¾-Inch omit the binder course and modify the thickness of the surface course.
3. Surface course and binder course mixtures must be placed on a dry, clean base and when weather conditions are suitable. In the event of a sudden rain, loading additional trucks must immediately stop whether it is from the plant or storage bins. Materials in transit will be permitted to be laid at the Contractor's risk providing the pavement is free of standing water and the proper temperature of the asphaltic mix is maintained. Approval to unload the trucks in transit in no way relaxes the requirements for quality, density or smoothness of the bituminous mixture being placed.
4. A preset grade reference device, i.e. 30 foot skid with electronic grading sensors, traveling on the adjacent pavement must be used for surface course placement.
5. Any foreign material on the existing surface must be removed to the satisfaction of the Commissioner before the surface course is placed.
6. In no case may the speed of the paver exceed 35 - feet per minute or as directed by the Commissioner.
7. "Flow Boys" must be used at all locations where vertical clearance precludes the use of normal dump trucks. The use of "Flow Boys" is considered incidental to the various HMA pay items and no additional payment will be made.
8. The Contractor must protect all sections of newly compacted surface courses from traffic until they have hardened to the satisfaction of the Commissioner.
9. Surface Tests must be made in accordance with applicable portions of 406.11 of the SSRBC. The Contractor must furnish a sixteen foot straight edge for use by the Commissioner. The Contractor will be responsible for straight edging the surface course before the surface course is opened to traffic.
10. The Contractor must furnish the name(s) of the QC manager and Level I Technician assigned to the project at the time of the Preconstruction meeting.

E. REFLECTIVE CRACK CONTROL

1. Reflective crack control treatment must be installed in accordance with requirements of Section 443.06 of the SSRBC. Locations for installing the reflective crack control treatment will be determined by the Commissioner or agency having jurisdiction over the roadway.

3.05 TRAFFIC CONTROL

A. The Contractor is responsible for traffic control and the protection of vehicular and pedestrian traffic from the work. For detailed requirements see Section 015526.

3.06 FIELD QUALITY CONTROL

A. Testing and Inspecting: Contractor must provide an IDOT qualified Hot Mix Asphalt testing agency to perform tests and inspections and to submit reports for Work of this Section.

B. Coring must be conducted using procedures and equipment that will provide undamaged, undistorted cores of a diameter of no less than 3-5/8-Inches. The hole caused by the removal of the cores must be refilled immediately with a bituminous meeting these specifications, compacted and finished to the satisfaction of the Commissioner. The Contactor must transport obtained cores to the plant laboratory for density determination. Determination of bulk specific gravity of cores will be performed using procedures specified in IL 166-86 or, if applicable IL 275-86. No less than 4 or more than 20 cores per day will be required by the Commissioner for the purpose of acceptance and / or compaction with nuclear gage density measurements. The cost of this work will not be paid for separately, but will be considered incidental to the various HMA pay items.

C. Hot Mix Asphalt Tests: Testing of Hot Mix Asphalt must comply with Article 1030.05 of the SSRBC.

1. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The work of ASPHALT PAVEMENT shall not be measured for payment.

4.02 PAYMENT

A. No separate payment shall be made for the work covered in this section. Payment for the Work of ASPHALT PAVEMENT shall be included in the contract lump sum price as shown in the Schedule of Prices for CIVIL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 020000.

END OF SECTION 32 12 16

SECTION 32 12 17

PROTECTIVE COAT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section specifies the requirements for applying a protective treatment to the permanently exposed surfaces of all Portland Cement Concrete placed in this project. The work under this Section must include all labor, materials, tools and equipment required for cleaning the concrete surface to be covered and applying a minimum of two coats of the protective surface treatment.

B. Except as modified herein, the work must be done in accordance with the applicable portions of Section 503.19 of the IDOT Standard Specifications.

C. Related Sections

1. Section 321621: Concrete Curbs, Gutters and Walks.
2. Section 321623: Portland Cement Concrete Sidewalk, 5-Inch.
3. Section 321623.10: Portland Cement Concrete Sidewalk, Special.

1.03 REFERENCES

A. Illinois Department of Transportation (IDOT) Standard Specifications for Road and Bridge Construction, Adopted April 1, 2016 or latest edition.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The Work of PROTECTIVE COAT will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the Work of PROTECTIVE COAT will be included in the contract lump sum price as shown in the Schedule of Prices for CIVIL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 020000.

END OF SECTION 32 12 17

SECTION 32 13 13

CONCRETE PAVEMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes requirements for Portland Cement Concrete Pavement as required for the roadway base courses proposed with the project improvements.

1.03 RELATED SECTIONS

A. Section 015526 – Traffic Control.

B. Section 031000 – Concrete Formwork

C. Section 032000 – Concrete Reinforcement and Embedded Assemblies

D. Section 312313 – Subgrade Preparation

E. Section 321116 – Sub-Base Granular Material Type B

F. Appendix B – CDOT Special Provisions

1.04 REFERENCES*

A. CDOT Regulations for Openings, Construction, and Repair in the Public Way, July 2012 (Specifications)

B. IDOT Standard Specifications for Road and Bridge Construction (SSRBC), latest edition.

C. IDOT Supplemental Specifications and Recurring Special Provisions (SSRSP). Latest edition.

*In the event of a conflict between CDOT and IDOT Specifications in this Section, CDOT Specifications shall govern.

1.05 MATERIAL TESTING, INSPECTIONS, AND SUBMITTALS

A. All materials and workmanship are subject to inspections, testing, and approval by the Commissioner.

B. Unless otherwise designated by the Commissioner, all tests must be conducted to current CDOT standards.

C. Contractor must provide an independent material testing agency to conduct testing and inspection. All provisions for test, samples and inspections are considered incidentals to the work and no additional payment is allowed.

D. Failure of the Contractor to pass required tests and inspections is grounds for rejection of the Work. All rejected Work is subject to removal or other corrective actions as directed by the Commissioner.

1.06 QUALITY ASSURANCE

A. Conformance with Specifications. Comply with this Section and CDOT Specifications for all work within public right-of-way. In the event that a conflict exists between this Section and the CDOT Specifications, CDOT Specifications govern. Work, which is not within CDOT jurisdiction, must be coordinated with the Commissioner to ensure compliance to all standards and permit requirements.

B. Material Tickets. Deliver to the Commissioner, at the time of delivery, a weight ticket for all material delivered signed by a Certified Public Weigh master indicating the net weight or volume and mix or type of material being delivered.

C. QC/QA. Provide quality control (QC) and quality assurance (QA) in accordance with the IDOT SSRSP Check Sheet #31 "Quality Control / Quality Assurance of Concrete Mixes".

PART 2 - PRODUCTS

2.01 AGGREGATE

A. Meet requirements of Article 1004 of the Standard Specifications for coarse aggregate with gradation of CA-6.

2.02 PORTLAND CEMENT CONCRETE

A. Meet requirements of Article 1020 of the Standard Specifications for Class PV Concrete.

2.03 DOWEL BARS AND PAVEMENT REINFORCING

A. Meet requirements of Article 1006 of the Standard Specifications.

2.04 JOINT FILLER

A. Meet requirements of Articles 1050 or 1051 of the Standard Specifications.

2.05 PROTECTIVE COAT FOR CONCRETE SURFACES

A. Meet requirements of Article 1023 of the Standard Specifications.

PART 3 - EXECUTION

3.01 GENERAL

A. If the limits of excavation of the trench width and/or the edge of the cut lines are exceeded during excavation, the restoration limits must be extended to include the additional widths.

B. In order to assure a straight-line edge restoration, the Commissioner may extend the width of the pavement removal and restoration to the extent that may be deemed necessary to satisfy the intent of this Section.

C. Notification to CDOT

1. Notify the Commissioner and CDOT for inspection of work requiring CDOT approval by noon on the day prior to commencing additional work. If CDOT inspectors fail to perform the inspection within forty-eight (48) hours after notification, the Contractor may, after approval of the Commissioner, proceed with subsequent work.

D. Plating of Unattended Excavations

1. All unattended openings in streets, alleys, and driveways necessitated by the work under this contract, must be covered with steel plates of adequate thickness to provide protection to both vehicular and pedestrian traffic.
2. Steel plating subjected to vehicular traffic must be of a sufficient thickness to support AASHTO HS-20 traffic loadings. The size of the plating must be large enough to span the opening with sufficient overlap and must be firmly bedded and secured to the pavement surface to prevent rocking or movement. A bituminous ramp is to be provided around the perimeter of the plating as appropriate to provide a smooth transition between surface of the plate(s) and the surrounding pavement or walkway, unless authorized otherwise. The use of steel plating during winter construction must be approved by CDOT and conform to their applicable requirements.
3. The name of the Contractor must be marked on both sides of each plate.
4. Plating of openings is not intended as a substitution for providing traffic control. Traffic control is to be provided in accordance with Section 015526 of these specifications.

3.02 PORTLAND CEMENT CONCRETE PAVEMENT

A. Pavement Base Course

1. Construct sub-base as shown on the Drawings, or as directed by the Commissioner. Work is to be in accordance with Section 311 of the SSRBC.
2. Construct Portland cement Concrete base as shown on the Drawings, or as directed by the Commissioner. Work is to be in accordance with Section 353 of the SSRBC after the sub-base has been placed and compacted. Provide dowel bars and tie bars for connections to the existing concrete pavement in accordance with Chapter 6 of the CDOT Specifications.
3. Limits for restoration for concrete base course are to be the width of the trench neat lines plus one additional foot on each side of the trench unless noted otherwise on the Drawings. If the gutter line or edge of pavement is at a distance of 2-feet or less from the edge of excavation, the pavement is to be restored from the edge of the trench excavation to the gutter line or edge of pavement.

B. Portland Cement Concrete Pavement (Where Applicable)

1. Construct Portland cement concrete pavement as shown on the Drawings and in accordance with Section 420 of the SSRBC. Provide dowel bars and tie bars for connections to existing concrete pavement, and reinforce Portland cement concrete pavement with pavement fabric in accordance with Chapter 6 of the CDOT Specifications, unless otherwise specified, or directed by the Commissioner.

C. Protective Coat for Concrete Surfaces

1. A Protective Coat must be applied to all concrete surfaces constructed and opened to traffic between October 15th and April 15th. The application of the Protective Coating should be applied in accordance with the requirements of Article 420.18 of the SSRBC.

D. Protection from Extreme Temperatures

1. It is the responsibility of the contractor, at no cost to the City, to provide temperature controlled concrete during hot weather in accordance with SSRBC Article 1020.14(a) and 1020.14(c).
2. It is the responsibility of the contractor to provide temperature controlled concrete during cold weather in accordance with SSRBC Article 1020.14(a) and 1020.14(c).
3. Protect new concrete in accordance with SSRBC Article 1020.13(c) for protection.

3.03 TRAFFIC CONTROL

A. The Contractor is responsible for traffic control and the protection of vehicular and pedestrian traffic from the work. For detailed requirements see Section 015526.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The work of CONCRETE PAVEMENT shall not be measured for payment.

4.02 PAYMENT

A. No separate payment shall be made for the work covered in this section. Payment for the Work of CONCRETE PAVEMENT shall be included in the contract lump sum price as shown in the Schedule of Prices for CIVIL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 020000.

END OF SECTION 32 13 13

SECTION 32 14 40
STONE PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Stone paving, including the following:

1. Stone pavers.
2. Stone Compass rose.
3. Stone curbs.

B. Related Sections:

1. Joint sealants: Section 07 92 00.

1.3 DEFINITIONS

A. Compass Rose is fabricated from natural multi-colored and shaded stone (granite) pieces cut to sizes and shapes set into design and graphics indicated, including north arrow in flat cut stainless steel letters and symbols, that is adhered to a granite backer piece. Compass Rose assembly is set flush into stone paving at indicated location.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Meetings: Conduct at Project site.

1.5 PERFORMANCE REQUIREMENTS

A. Delegated Design:

1. Design, engineer, fabricate, and install stone paving work in compliance with specified standards, performance requirements, material selections and requirements of this and related sections.
2. Include engineering analysis by a qualified Engineer, using structural performance requirements and design criteria indicated herein.
3. Coordinate concrete slab work with results of engineering analysis.

B. Stone Testing: Perform the following tests on random samples of stone quarried for the project.

1. Absorption, and Bulk Specific Gravity (Density): ASTM C97. Two tests each.
2. Compressive strength: ASTM C170. Four tests. Apply loading parallel or perpendicular to the rift plane, whichever will be the loaded condition of stone used in the work.
3. Modulus of Rupture: ASTM C99. One group of 30 tests dry. One group of 30 tests wet. Apply loading parallel or perpendicular to the rift plane, whichever will be the loaded condition of stone used in the Work.
4. Flexural Strength: ASTM C880. One group of 30 tests dry. One group of 30 tests wet. Apply loading parallel or perpendicular to the rift plane, whichever will be the loaded condition of stone used in the Work.
5. Abrasion Resistance: ASTM C241. One test of each type stone to be used for walking surfaces.
6. Static Coefficient of Friction: ASTM C1028. Test each combination of stone and surface finish to be used for walking surfaces. Slip resistance tests must be performed by a qualified independent testing agency.
7. Petrographic Analysis: ASTM C295. One test.
8. Compressive Strength of Mortars: ASTM C 109. Provide setting bed mortar not less than 4,000 psi. Provide test data to substantiate this requirement.

C. Dynamic Coefficient of Friction (DCOF): Provide flooring surfaces, including sealer, with a minimum of 0.42 DCOF when tested in accordance with ANSI A326. 3.

1.6 ACTION SUBMITTALS

A. Product Data: For the following:

1. Each stone type.
2. Mortar and grout materials.
3. Surface sealers.
4. Cleaning products.
5. Granite backer for Compass Rose

B. Samples for Verification:
1. Grout Samples for Initial Selection: Manufacturer's standard samples of actual products showing the full range of colors available.
2. Grout Samples for Verification: For each color required, showing the full range of exposed color and texture expected in completed Work.
3. Paving Stone Sealer: Three 12 inch x 12 inch samples of each specified stone paving with one-half coated with the specified sealer.
4. Stone Samples for Verification: Sets for each color, grade, finish, and variety of stone required; not less than 12 inches square. Include three or more samples in each set showing the full range of variations in appearance characteristics expected in completed Work.

C. Shop Drawings:
1. Floor plans showing layouts and dimensions of each stone unit. Indicate building and site walls, items and construction to which paving will abut or terminate.

2. Show details of fabrication and installation of stone paving, including dimensions and profiles of stone units; arrangement and details of jointing; and details showing relationship with, attachment to, and reception of related work.
3. For Compass Rose assembly indicating design, sizes, dimensions, joint patterns, graphics, lettering, location of each color, shade, and texture of stone and other design features. Shop drawings to indicate profiles and sections for assembly and details.
4. Indicate location of Compass Rose installation with dimensions and relationship to street and to adjacent elements. Shop drawings to indicate actual north arrow indication. Shop drawings to show installation details, profiles of installation and any special installation or substrate conditions.

1.7 INFORMATIONAL SUBMITTALS

A. Adhesion and Compatibility Test Reports: From latex-additive manufacturer for mortar and grout containing latex additives.

B. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for unit pavers, indicating compliance with requirements.

C. Material Certificates: For unit pavers. Include statements of material properties indicating compliance with requirements, including compliance with standards. Provide for each type and size of unit.

D. Maintenance data to be included in the Maintenance Manual specified in Division 01 Section "Contract Closeout." Furnish information describing the materials, equipment, and procedures to be followed for the cleaning and maintenance of the stone used in the work.

A. Qualification Data: For Engineer.

B. Design Calculations: Submit calculations prepared by a qualified Engineer, showing compliance with the specified performance criteria. Calculations will not be reviewed by the Architect but are for informational purposes only. Test reports are not an acceptable substitute for design calculations.

C. Warranty: Signed copies of warranty of terms specified herein.

1.8 QUALITY ASSURANCE

A. Engineer Qualifications: Structural Engineer licensed in the State of Illinois and experienced in providing engineering services of the kind indicated that have resulted in the successful installations, similar in material, design, and extent to that indicated for this Project.

B. Installer Qualifications: Engage an experienced installer who has completed stone paving similar in material, design, and extent to that indicated for project that has resulted in construction with a record of successful in-service performance.

C. Fabricator Qualifications: Engage a firm experienced in producing stone paving similar to that indicated for this project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units without delaying the Work.

D. Source Limitations for Stone: Obtain each variety of stone, regardless of finish, from a single quarry with resources to provide materials of consistent quality in appearance and physical properties and to cut and finish material without delaying the Work.

1. Granite: Obtain each type of granite specified from one quarry, with consistent color range and texture throughout the work. Comply with the requirements of the National Building Granite Quarries Association, Inc., (NBGQA) for color and finish. Sources or kinds of materials as specified and reviewed are not to be changed during the course of the Work.

E. Source Limitations for Other Materials: Obtain each type of cementitious material, grout, admixture, stone accessory, sealant, and other material from a single manufacturer for each product.

F. Factory Inspections:

1. Provide for the Commissioner's representatives to visit the factory where the stone paving is being fabricated. Do not ship the stone paving without the written approval of the Commissioner after conclusion of the factory visit.

G. Mockup: Unless approved otherwise by the Commissioner, Compass Rose fabricator to provide full size mockup of the Compass Rose, Type B, including stone, stainless steel trim, letter inlay assembly. Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.
1. Approval of mockup does not constitute approval of deviations from the Contract Documents contained in mockups unless Commissioner specifically approves such deviations in writing.
2. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.9 DELIVERY, STORAGE AND HANDLING

A. Store pavers on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied.

B. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.

C. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.

D. Store liquids in tightly closed containers protected from freezing.

1.10 PROJECT CONDITIONS

A. Cold-Weather Protection: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen subgrade or setting beds. Remove and replace work damaged by frost or freezing.

A. Weather Limitations for Mortar and Grout: weather construction requirements contained in TMS 602/ACI 530.1/ASCE 6.

1.11 WARRANTY

A. Provide written warranty stating that the stone paving and Compass Rose installation is to be free of faults and defects in the materials and workmanship. Faults and defects include but are not necessarily limited to abnormal visual deterioration, aging, discoloration, material and structural failure of materials, excessive deflections, delamination, cracking and surface deterioration.

B. Provide warranty for a period of 5 years from the date of final acceptance.

C. Stone paving found to be defective or not complying with the Contract Documents during the warranty period is to be promptly repaired and/or replaced after written notice by the Commissioner, unless the Commissioner has previously given written acceptance of such conditions.

1. If exploratory work is required to determine the cause of defects, the cost of exploratory work is be borne by the Contractor when that portion of the work is found defective or in non-compliance with the Contract Documents.
2. Included in the warranty is the obligation to continue corrective measures to defective work beyond the warranty period if initial corrective measures where executed and latter found to be inadequate or in non-compliance with the Contact Documents after the warranty period.

D. Provide copies of warranty signed by the Stone Paving Installer, Stone Paving Manufacturer, Paving Setting Products Manufacturer.

E. This warranty is in addition to, and not a limitation of, other rights the Commissioner may have under the Contract Documents.

PART 2 - PRODUCTS

2.1 GRANITE

A. Granite Dimension Stone Standard: ASTM C 615.

1. Granite: As specified by National Building Granite Quarries Association, Inc. (NBGQA) in "Specifications for Architectural Granite."

B. Granite Properties: Conform to the following physical requirements:

1. Absorption: Maximum 0.4% by weight Density: Maximum 160 pcf. per ASTM C97.
2. Compressive Strength: Minimum 19,000 psi per ASTM C170.
3. Modulus of Rupture: Minimum 1500 psi per ASTM C99.
4. Flexural Strength: Minimum 1200 psi per ASTM C 880.
5. Abrasion Resistance: ASTM C241.
6. Minimum abrasive hardness of 25 for stone subjected to foot traffic.

C. Sources which may be incorporated in the work include, but are not limited to, the following:

1. Coldspring
   17482 Granite West Rd
   Cold Spring, MN
   1.800.328.5040
   320.685.4615
   http://www.coldspringusa.com/

2. Fletcher Granite
   15 Branch Pike
   Smithfield, RI 02917
   401-232-2040
   www.fletchergranite.com

3. Rock of Ages
   560 Graniteville Road
   Graniteville, VT 05654
   877-870-9057
   www.rockofages.com

4. The North Carolina Granite Corporation
   PO Box 151
   Mount Airy, NC 27030
   1.800.227.6242
   708.672.0136
   www.ncgranite.com

2.2 STONE

A. Granite: Paving slabs made from granite complying with ASTM C 615/C 615M.

1. Color and Grain (Basis of Design):
   a. STN-01A (White): Interior Field Paver, Coldspring – (ROCKVILLE WHITE)
   b. STN-01B (White): Exterior Field Paver, Coldspring – (ROCKVILLE WHITE)
   c. STN-02A (Black): Interior Accent Paver, Coldspring – (MESABI BLACK)
   d. STN-02B (Black): Exterior Accent Paver, Coldspring – (MESABI BLACK)
2. Finish: Thermal Finish.
3. Thickness: As indicated on Drawings, not less than 1-1/4 inches unless otherwise indicated.

4. Face Size: As indicated on Drawings.

B. Granite Curbs: Match paving slabs. Fabricate to indicated shape.

C. Each color of granite to be from a single quarry and match the color, texture, variety and quality of stone selected and approved by the Commissioner.

1. Extract blocks of each type and color from a single bed of quarry stratum reserved for this Project.
2. Select stones from selected blocks visually acceptable to Commissioner.

D. Source Approval by Commissioner: Make quarried and cut blocks available for Commissioner's approval during quarry operation and prior to shipment to fabricator or prior to fabrication.

E. Fabricator to coordinate and inspect quarrying for this Project to ensure quarried block orientations produce finished stone with specified characteristics.

F. Provide stone that is free of cracks, seams, and defects that would impair structural integrity, durability, appearance, or function, and from a single quarry for each stone type with the characteristics listed below.

2.3 ACCESSORIES

A. Stainless steel: ASTM A 240/A 240M, UNS S31600.

B. Compressible Foam Filler: Preformed strips complying with ASTM D 1056, Grade 2A1.

C. Cleaner: Provide stone cleaners specifically formulated for stone types, finishes, and applications indicated as specified by stone producer, and by sealer manufacturer. Do not use cleaning agents containing acid or cleaning compounds and solutions containing caustic or harsh fillers, except where expressed by written approval from the stone producer and sealer manufacturer for stone type condition.

D. Floor Sealer: Colorless, slip- and stain-resistant sealer, not affecting color or physical properties of stone surfaces as recommended by stone fabricator for application indicated.

E. Compass Rose Backer Stone: 3/4 inch thick smooth granite slab. One piece cut to size of entire granite assembly.

F. Compass Rose Epoxy: as recommended and approved by the stone fabricator to set and secure granite pieces to backer stone and to each other for Compass Rose. Subject to compliance with requirements, provide one of the following:
1. AKA-Bond - Akabond 621 KG
2. McKinnon - Stone Bond Epoxy
3. Laticrete – Latapoxy 300

2.4 MORTAR SETTING-BED MATERIALS

A. Portland Cement: ASTM C 150/C 150M, Type I or Type II.

B. Hydrated Lime: ASTM C 207, Type S.

C. Sand: ASTM C 144.

D. Latex Additive: Manufacturer's standard water emulsion of type specifically recommended by latex-additive manufacturer for use with field-mixed portland cement and aggregate mortar bed, and not containing a retarder.

E. Thin-Set Mortar for Bond Coat: Latex-portland cement mortar complying with ANSI A118.4.

F. Water: Potable.

G. Reinforcing Wire Fabric: Galvanized, welded wire fabric, 2 by 2 inches by 0.062 inch in diameter; comply with ASTM A 185/A 185M and ASTM A 82/A 82M except for minimum wire size.

2.5 GROUT MATERIALS

A. Sand-Portland Cement Grout: ANSI A108.10, made of white or gray cement and white or colored aggregate as required to produce color indicated.

1. Colored Mortar Pigments for Grout: Natural and synthetic iron and chromium oxides, compounded for use in mortar and grout mixes. Use only pigments that have proved, through testing and experience, to be satisfactory for use in portland cement grout.

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Davis Colors.
2) Solomon Colors, Inc.

B. Standard Cement Grout: ANSI A118.6, sanded.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Custom Building Products.
b. H.B. Fuller Construction Products Inc. / TEC.
c. LATICRETE SUPERCAP, LLC.
d. MAPEI Corporation.

C. Grout Colors: As selected by Commissioner from manufacturer's full range.

D. Water: Potable.

2.6 MORTAR AND GROUT MIXES

A. General: Comply with referenced standards and with manufacturers' written instructions for mix proportions, mixing equipment, mixer speeds, mixing containers, mixing times, and other procedures needed to produce setting-bed and joint materials of uniform quality and with optimal performance characteristics. Discard mortars and grout if they have reached their initial set before being used.

B. Mortar-Bed Bond Coat: Mix neat cement and latex additive to a creamy consistency.

C. Portland Cement-Lime Setting-Bed Mortar: Type M complying with ASTM C 270, Proportion Specification.

D. Latex-Modified, Portland Cement Setting-Bed Mortar: Proportion and mix portland cement, sand, and latex additive for setting bed to comply with written instructions of latex-additive manufacturer and as necessary to produce stiff mixture with a moist surface when bed is ready to receive pavers.

E. Latex-Modified, Portland Cement Bond Coat: Proportion and mix portland cement, aggregate, and liquid latex for bond coat to comply with written instructions of liquid-latex manufacturer.

F. Thinset Mortar Bond Coat: Proportion and mix according to manufacturer's written instructions.

G. Job-Mixed Portland Cement Grout: Proportion and mix job-mixed portland cement and aggregate grout to match setting-bed mortar except omit hydrated lime and use enough water to produce a pourable mixture.

1. Pigmented Grout: Select and proportion pigments with other ingredients to produce color required. Do not exceed pigment-to-cement ratio of 1 to 10, by weight.
2. Colored-Aggregate Grout: Produce color required by combining colored aggregates with portland cement of selected color.

H. Packaged Grout: Proportion and mix according to grout manufacturer's written instructions.

2.7 COMPASS ROSE FABRICATION

A. General: Fabricate stone Compass Rose assembly in sizes, design and shapes required to comply with requirements indicated, including details on Drawings, final shop drawings, and approved sample, if applicable.

B. Cut different colored stones to fit Compass Rose pattern, graphics, and lettering as indicated on Drawings, final shop drawings and approved sample. Produce units within fabrication tolerances specified by applicable stone association or stone source.

C. Face Sizes, design, colors and graphics: As indicated on drawings, final shop drawings, and approved samples. Lettering, size and fonts as shown on drawings or as otherwise submitted and approved by the Commissioner.

D. Stone Edges: Square.

E. Produce joints of uniform width as indicated. Joints to be as tight as possible.

F. Clean sawn backs of stones to remove rust stains and free iron particles.

G. Flatness Tolerances: Maximum variations for honed, and fine-rubbed surfaces at bed and joint arris lines; 3/64 inch or 1/16 of specified joint width, whichever is greater.

1. Beds and Joints: Bed and joint surfaces cut or sawn full square for specified minimum thickness of unit.
2. Backs sawn or roughly dressed to approximate true planes. Maximum variation plus or minus 1/8 inch.

H. Finish exposed faces and edges of stones to comply with requirements indicated for finish under each type and application of stone and to match approved samples and mockup.

I. Carefully inspect finished stones at fabrication plant for compliance with requirements relative to qualities of appearance, material, and fabrication. Replace defective stones with units that comply.

1. Grade and mark stones for overall uniform appearance when assembled in place. Natural variations in appearance are acceptable if installed stones match range of colors and other appearance characteristics are represented in approved samples and mockups.

2.8 COMPASS ROSE ASSEMBLY

A. Set and adhere granite pieces in design indicated and approved with required graphics to granite backer with epoxy. Joints between granite pieces to be even and tight with epoxy at the joints between granite pieces. Edges to be smooth and free of defects. Follow epoxy manufacturer’s directions and recommendations for preparation of surfaces, application, curing, and environmental conditions for epoxy installation. Design, graphics and spacing to be true to their geometric shapes, true to lines, parallel, centered, with even spacings. Letters and north arrow to be at proper orientations.

B. Set stones to comply with Drawings, final shop drawings, and approved samples and mockup.

C. Do not use stone units with chips, cracks, voids, stains, or defects visible in the finished work.

D. Match stones for color and pattern for uniformity and to match.

E. Wash stone unit faces to remove loose material and soil.

F. Scribe and cut stone as necessary to fit design. Produce neat and tight joints.

G. Set individual stones for border and design onto granite backer slab. Surfaces to be clean, flat, even and without projections to assure continuous contact. Take care to maintain accurate surface, joint alignment and spacing. Apply epoxy to required surfaces according to directions and recommendations. Tap stone into place to ensure 100 percent contact between back of stone and backer stone and contact at stone joints. Take care to maintain accurate surface, joint alignment, and spacing. Do not realign stone after epoxy has taken initial set.

H. Entire Compass Rose Assembly to have an even and flat surface.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces indicated to receive unit paving, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Where unit paving is to be installed over waterproofing, examine waterproofing installation, with waterproofing Installer present, for protection from paving operations, including areas where waterproofing system is turned up or flashed against vertical surfaces.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Remove substances from substrates that could impair mortar bond.

B. Sweep substrates to remove dirt, dust, debris, and loose particles.

3.3 PAVER INSTALLATION

A. Do not use pavers with chips, cracks, voids, discolorations, or other defects that might be visible or cause staining in finished work.

B. Mix pavers from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.

C. Cut unit pavers with motor-driven masonry saw equipment to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible. Hammer cutting is not acceptable.

D. Joint Pattern: As indicated in Drawings.

E. Tolerances: Do not exceed 1/16-inch unit-to-unit offset from flush (lippage) nor 1/8 inch in 24 inches and 1/4 inch in 10 feet from level, or indicated slope, for finished surface of paving.

F. Expansion and Control Joints: Provide for sealant-filled joints at locations and of widths indicated in Drawings. Provide compressible foam filler as backing for sealant-filled joints unless otherwise indicated. Install joint filler before setting pavers. Sealant materials and installation are specified in Section 07 92 00 "Joint Sealants."

3.4 MORTAR SETTING-BED APPLICATIONS

A. Saturate concrete subbase with clean water several hours before placing setting bed. Remove surface water about one hour before placing setting bed.

B. Apply mortar-bed bond coat over surface of concrete subbase about 15 minutes before placing mortar bed. Do not exceed 1/16-inch thickness for bond coat. Limit area of bond coat to avoid its drying out before placing setting bed.

C. Apply mortar bed over bond coat; spread and screed mortar bed to uniform thickness at subgrade elevations required for accurate setting of pavers to finished grades indicated.

D. Place reinforcing wire over concrete subbase, lapped at joints by at least one full mesh and supported so mesh becomes embedded in the middle of mortar bed. Hold edges back from vertical surfaces approximately 1/2 inch.

E. Place mortar bed with reinforcing wire fully embedded in middle of mortar bed. Spread and screed mortar bed to uniform thickness at subgrade elevations required for accurate setting of pavers to finished grades indicated.

F. Mix and place only that amount of mortar bed that can be covered with pavers before initial set. Before placing pavers, cut back, bevel edge, and remove and discard setting-bed material that has reached initial set.

G. Place pavers before initial set of cement occurs. Immediately before placing pavers on mortar bed, apply uniform 1/16-inch- thick bond coat to mortar bed or to back of each paver with a flat trowel.

H. Tamp or beat pavers with a wooden block or rubber mallet to obtain full contact with setting bed and to bring finished surfaces within indicated tolerances. Set each paver in a single operation before initial set of mortar; do not return to areas already set or disturb pavers for purposes of realigning finished surfaces or adjusting joints.

I. Spaced Joint Widths: Provide 1/2-inch nominal joint width with variations not exceeding plus or minus 1/8 inch.

J. Grouted Joints: Grout paver joints complying with ANSI A108.10.

K. Grout joints as soon as possible after initial set of setting bed.

1. Force grout into joints, taking care not to smear grout on adjoining surfaces.
2. Clean pavers as grouting progresses by dry brushing or rubbing with dry burlap to remove smears before tooling joints.
3. Tool exposed joints slightly concave when thumbprint hard, using a jointer larger than joint thickness unless otherwise indicated.
4. If tooling squeezes grout from joints, remove excess grout and smears by dry brushing or rubbing with dry burlap and tool joints again to produce a uniform appearance.

L. Cure grout by maintaining in a damp condition for seven days unless otherwise recommended by grout or liquid-latex manufacturer.

3.5 COMPASS ROSE INSTALLATION

A. Form a recess in new concrete to accept the Compass Rose assembly. Size of recess in pavement to be size of Compass Rose assembly plus ¼ inch joint at perimeter. Depth of recess to be 2-1/2 inches or as necessary to allow flush installation of granite assembly.

B. If remaining depth of concrete after creating recess is insufficient structurally; for an installation at existing concrete, remove the concrete and pour a base of sufficient depth or, for an installation in new concrete, pour a thicker slab under the recess for the Compass Rose.

C. Cement Mortar Leveling Bed to be applied as slurry bond coat and screed bed for filling, patching and leveling of substrate as required to make ready for Compass Rose installation. Place leveling bed, screed to the level or slope as required to conform to the subsequent finish elevation, and allow the screed leveling bed to properly cure.

D. Set Compass Rose assembly in pavement recess. Apply a bed of mortar over leveling or setting bed substrate and apply to back of Compass Rose backer stone just prior to installation. Use a notched trowel and work the mortar into 100 percent contact with the surfaces. Set Compass Rose assembly into place on the setting bed. Place and thoroughly tamp the Compass Rose assembly into setting material to obtain 100 percent contact and permanent bond. Set and level assembly immediately maintaining uniform perimeter joint widths. Perimeter joints to be even and straight. Top surface of Compass Rose assembly to be level and align with adjacent paving surfaces.

E. Grout outside joint along entire perimeter between granite and pavement. After setting, rake joints and completely fill joints solid with specified grout, free from voids or pits. Tool grout flush with top surface of stone. Promptly remove excess and spillage from stone faces to prevent staining or defacement. Cover areas to provide proper moist curing.

3.6 INSTALLATION TOLERANCES

A. Variation in Surface Plane of Paving: Do not exceed 1/8 inch in 10 feet from level or slope indicated when tested with a 10-foot straight edge. Do not exceed ± 1/32" joint width variation at any location and 1/16" in 3' run variation in alignment of joints.

3.7 SEALER

A. Apply sealer to cleaned stone paving and Compass Rose Assembly according to sealer manufacturer's printed instructions.

3.8 PROTECTION

A. Prohibit traffic from installed stone for a minimum of 72 hours.

B. Protect set and grouted stone paving and Compass Rose assembly during construction with non-staining kraft paper. Where adjoining areas require construction work access, cover stone paving with a minimum of 3/4-inch untreated plywood over Kraft paper.

3.9 REPAIRING, POINTING, AND CLEANING

A. Remove and replace unit pavers that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment and with no evidence of replacement.

B. Pointing: During tooling of joints, enlarge voids or holes and completely fill with grout. Point joints at sealant joints to provide a neat, uniform appearance, properly prepared for sealant application.

C. Cleaning: Remove excess grout from exposed paver surfaces; wash and scrub clean.

1. Remove temporary protective coating as recommended by coating manufacturer and as acceptable to paver and grout manufacturers.
2. Do not allow protective coating to enter floor drains. Trap, collect, and remove coating material.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

A. The work of STONE PAVING will not be measured for payment.

4.2 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the work of STONE PAVING must be included in the contract lump sum price as shown in the Schedule of Prices for ARCHITECTURAL WORK.

4.3 PAY ITEM ACCOUNT NUMBER

A. Architectural work: 090000

END OF SECTION

SECTION 32 16 21

CONCRETE CURBS, GUTTERS & WALKS

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes requirements for restoration of Portland Cement Concrete Walkways, ADA Ramps, Curbs and Gutters and Miscellaneous Concrete.

1.03 RELATED SECTIONS

A. Section 032000 – Concrete Reinforcement.

B. Section 033000 – Cast-In-Place Concrete.

C. Section 321313 – Concrete Pavement.

D. Section 321726 – Tactile/Detectable Warning Surface Tiles.

1.04 REFERENCES

A. CDOT Regulations for Openings, Construction, and Repair in the Public Way (CDOT Specifications), July 2012.

B. CDOT Appendix B: Regulations for Openings, Construction, and Repair in the Public Way (ADA Standards), July 2012.

C. IDOT Standard Specifications for Road and Bridge Construction (SSRBC), latest edition.

D. IDOT Supplemental Specifications and Recurring Special Provisions (SSRSP), latest edition.

E. Americans with Disabilities Act (ADA): Title 49 CFR Transportation, Part 37.9 'Standards for Accessible Transportation Facilities, Appendix A, Section 4.29.2 Detectable Warnings on Walking Surfaces,' latest edition.

F. Illinois Administrative Code, Chapter 1, part 400.310 Subchapter B, latest edition.

G. California Code of Regulations (CCR): Title 24, Part 1, Articles 2, 3, and 4 and Part 2, Section 205, Section 1127B.5 and Section 1133B.8.5, latest edition.

1.05 MATERIAL TESTING, INSPECTIONS, AND SUBMITTALS

A. All materials and workmanship are subject to inspections, testing, and approval by the Commissioner.

B. Unless otherwise designated by the Commissioner, all tests must be conducted to current CDOT standards.

C. Refer to Book 1 for submittal requirements and procedures for Shop Drawings, Product Data, Records and Samples.

1. Submit manufacturer's literature describing products, installation procedures and routine maintenance.
2. Submit two (2) samples minimum 8" square of the Detectable Warning Tiles proposed for use.
3. Submit layout drawings for products specified showing plans of placement including joints, sizes, types and quantity of tiles to be used at each ramp, and an outline of installation materials and procedures.

D. Failure of the Contractor to pass required tests and inspections is grounds for rejection of the Work. All rejected Work is subject to removal or other corrective actions as directed by the Commissioner.

1.06 QUALITY ASSURANCE

A. Installer's Qualifications: Engage an experienced Installer certified in writing by Detectable Warning Tile manufacturer as qualified for installation, who has successfully completed installation similar in material, design and extent to that indicated for the Project.

B. Detectable Warning Tiles must be guaranteed in writing for a period of five years from date of final completion. The guarantee includes defective work, breakage, deformation and loosening of tiles.

C. Remove and replace concrete which does not satisfy the performance requirements of this specification, which does not conform to grades and profiles shown on the Drawings, contains cracks, spalling or other defects which impairs the strength, safety or appearance of the work, or has been damaged or discolored during construction. Protect the Work from damage until accepted.

D. Meet the requirements of CDOT ADA Standards Appendix B.

E. Meet the requirements of quality control (QC) of Specification 033000 Concrete.

PART 2 - PRODUCTS

2.01 PORTLAND CEMENT CONCRETE

A. Meet requirements of Section 033000 – Concrete.

2.02 PROTECTIVE COAT FOR CONCRETE SURFACES

A. Meet requirements of Section 033000 – Concrete.

2.03 DETECTABLE WARNING TILES

A. Provide detectable warning tiles from manufacturers approved by CDOT in accordance with CDOT Standards and Specifications. These include but are not limited to the following:

1. East Jordan Iron Works
2. Neenah Foundry
3. Pioneer Detectable, LLC
4. Advantage Cast Iron

2.04 JOINT FILLER

A. Meet requirements of Section 033000 – Concrete.

2.05 DOWEL BARS AND PAVEMENT REINFORCING

A. Meet requirements of Section 032000 – Concrete Reinforcement and Embedded Assemblies

PART 3 - EXECUTION

3.01 SIDEWALKS

A. Excavate, prepare and compact subgrade to 95% of maximum laboratory density and in accordance with SSRBC Section 424.

B. Construct Portland cement concrete sidewalk in accordance with Section 424 of the SSRBC. Construct Portland cement concrete sidewalk 5-inches thick in one (1) course where shown on the drawings, or as directed by the Commissioner.

C. Restore to the original conditions areas damaged by the contractor during the removal and/or installation of the new sidewalk. This includes all existing

parkway including brick, grass and asphalt, sidewalk, concrete base, and pavement

D. Cross slopes of sidewalks must be a minimum to provide positive drainage to curb and a maximum of 2%.

3.02 ADA RAMPS / DETECTABLE WARNING TILES

A. The Contractor is solely responsible for the construction of the ramps in accordance with the American with Disabilities Act (ADA) and CDOT Appendix B Requirements for Openings, Construction, and Repair in the Public Way (ADA Standards)

B. Detectable Warning Tiles and Anchors must be installed in accordance with manufacturer's recommendations and CDOT requirements.

C. Transportation and Delivery

1. Deliver Detectable Warning Tiles to worksite in such quantities and at such times to assure continuity of installation. Handle and transport units in a position consistent with their shape and design in order to avoid excessive stresses or damage.
2. Store units at worksite to prevent cracking, distorting, and warping, staining or other physical damage and so that markings are visible.
3. Keep panels under cover and protected until installed.
4. Deliver anchors in sufficient quantity for the work to be done before the start of construction.

D. Environmental Conditions and Protection: Maintain minimum temperature of forty (40) degrees Fahrenheit in spaces to receive Detectable Warning Tiles for at least forty-eight (48) hours prior to installation, during installation, and for not less than forty-eight (48) hours after installation. Maintain minimum temperature of forty (40) degrees Fahrenheit in storage spaces where tile material will be stored for at least forty-eight (48) hours before beginning installation.

E. Excavate, prepare and compact subgrade to 95% of maximum laboratory density and in accordance with SSRBC Section 424. When directed by the Commissioner, provide 3-Inch sand sub-base under new sidewalks in parkways or when a change in the subgrade elevation occurs.

F. Construct Portland cement concrete sidewalk in accordance with Section 424 of the SSRBC and the City of Chicago Department of Transportation's latest Standard Drawing for Curb Ramps for People with Disabilities. Construct curb ramps and side flares a uniform 8-Inch thick in one (1) course where shown on the drawings, or as directed by the Commissioner.

G. The concrete must be poured and finished, true and smooth to the required dimensions and slope prior to tile placement. Immediately after finishing the concrete, check that the required slope is achieved. Place the tile true and

square to the curb edge in accordance with the contract drawings. Tamp or vibrate the Cast-In-Place Tiles into the fresh concrete to ensure that the field level of tile is flush to the adjacent concrete surface. Ensure that the tile field level is flush to adjacent surfaces to permit proper water drainage and eliminate tripping hazards between adjacent finishes. The tolerance for elevation differences between tile and adjacent surface is ±1/16". Place the second panel next to the first, leaving no gap (tiles must be abutted to one another) and press into the wet concrete. Set adjacent panels even and level with each other and with the surrounding concrete

H. Before the concrete has set, trowel the concrete flat around the tile perimeter to the field level of the tile. Remove any excess concrete, leaving no gap (tiles must be abutted to one another) between the panels. Apply broom finish to the area immediately surrounding the panels

I. Following tile placement, review installation tolerances to contract drawings and adjust tile before the concrete sets. Place a minimum of two (2) suitable weights of 25 lb each on each tile to ensure solid contact of tile underside to the concrete

J. Remove the protective plastic coating and insert one anchor into each of the preformed holes. The anchors must be set flush to the panel surface. Tap the top of each anchor to ensure contact of the concrete with the anchor.

K. During and after the tile installation and the concrete curing stage prevent exertion of external forces upon the tile.

L. Following the curing of the concrete, remove the protective plastic wrap from the tile face. Prevent damage to the tile surface while removing the plastic wrap and /or and concrete residue. Tile surface must be clean prior to final inspection and acceptance.

M. Protect tiles against damage during construction period to comply with tile manufacturer's specification. Tiles damaged prior to placement will not be acceptable for installation and must be replaced at the Contractor's cost.

N. Protect tiles against damage from rolling loads following installation.

O. Clean tiles not more than four days prior to date scheduled for inspection intended to establish date of substantial completion in each area of project. Clean tile by method specified by tile manufacturer.

3.03 CONCRETE CURB AND COMBINATION CURB AND GUTTER

A. Construct concrete curb and combination concrete curb and gutter as shown on the Drawings, or as directed by the Commissioner. Construction must be in conformance with Section 606 of the SSRBC.

3.04 PROTECTIVE COAT

A. Apply protective coats of linseed oil and petroleum spirits to concrete sidewalks, curbs and gutters constructed between October 15 and April 15. The application of protective coat must conform to the requirements of Article 420.18 of the SSRBC. Provide sand to prevent slipping on walking surfaces open to traffic.

3.05 PROTECTION FROM EXTREME TEMPERATURES

A. It is the responsibility of the contractor, at no additional cost to the City, to provide temperature controlled concrete during hot weather in accordance with SSRBC Article 1020.14(a) and 1020.14(c).

B. It is the responsibility of the contractor, at no additional cost to the City, to provide temperature controlled concrete during cold weather in accordance with SSRBC Article 1020.14(a) and 1020.14(c).

C. Protect new concrete in accordance with CDOT and IDOT Standards.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The work of CONCRETE CURBS, GUTTERS AND WALKS shall not be measured for payment.

4.02 PAYMENT

A. No separate payment shall be made for the work covered in this section. Payment for the Work of CONCRETE CURBS, GUTTERS AND WALKS shall be included in the contract lump sum price as shown in the Schedule of Prices for CIVIL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 020000.

END OF SECTION 32 16 21

SECTION 32 16 23

PORTLAND CEMENT CONCRETE SIDEWALK, 5 INCH

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section specifies requirements for sidewalk. The work under this Section will include furnishing all labor, materials, tools and equipment required to construct PORTLAND CEMENT CONCRETE SIDEWALK, 5-INCH, including, but not limited to, all joints, fillers, dowel bars, subgrade preparation, sub-base materials, protective coating and its application and other appurtenant items associated with construction of this item.

B. Except as modified herein, the work must conform to the applicable portions of the Standard Specifications (IDOT), Section 424 and to the applicable portions of the CDOT QC/QA program which is in accordance with Check Sheet 31 of IDOT's Recurring Special Provisions, and shall take precedence over all other specifications.

C. Related Sections:

1. Section 031000: Concrete Formwork
2. Section 032000: Concrete Reinforcement and Embedded Assemblies
3. Section 033000: Cast-In-Place Concrete
4. Section 312313: Subgrade Preparation.
5. Section 321116: Sub-base Granular Material, Type B.
6. Section 321217: Protective Coat.
7. Section 321621: Concrete Curbs, Gutters and Walks.

1.03 REFERENCES

A. Illinois Department of Transportation (IDOT) Standard Specifications for Road and Bridge Construction, Adopted April 1, 2016 or latest edition.

1.04 SUBMITTALS

A. The Contractor must submit the proposed concrete mix designs for the review and approval of the Commissioner.

PART 2 - PRODUCTS

2.01 PORTLAND CEMENT CONCRETE: SIDEWALK Concrete must conform to the applicable portions of Section 1020 of the Standard Specifications. Concrete must be Class SI Concrete, compressive strength of 3500 psi at 14 days.

2.02 Concrete surface must receive a Brush Finish, as per Article 424.06 of the Standard Specifications.

2.03 Concrete control joints must be spaced between 4 to 6 feet on center, as per Article 424.06 of the Standard Specifications.

2.04 Expansion joint material must be bituminous preformed joint filler conforming to Article 1051.03 of the Standard Specifications.

PART 3 - EXECUTION

3.01 Protective coat must be applied on all sidewalk constructed herein, in accordance with Section 420.21 of the Standard Specifications regardless of time of year.

3.02 Concrete testing for PORTLAND CEMENT CONCRETE SIDEWALK, 5 INCH must be completed as specified in the standard CDOT QC/QA program which is covered in IDOT's Recurring Special Provision Check Sheet 31.

3.03 Compacted Sub-base Granular Material, Type B as specified in Section 321116 must be placed beneath all sidewalks on a prepared subgrade, placed and compacted to a minimum depth of five inches.

3.04 The Contractor must provide expansion joints at forty (40) foot intervals in long runs of sidewalks and wherever sidewalk abuts curbs, paving, structures or elsewhere as shown on the plans. Joint size must be as specified in Article 424.07 of the Standard Specifications (IDOT).

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The Work of PORTLAND CEMENT CONCRETE SIDEWALK, 5 INCH will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the Work of PORTLAND CEMENT CONCRETE SIDEWALK, 5 INCH will be included in the contract lump sum price as shown in the Schedule of Prices for CIVIL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 020000.

END OF SECTION 32 16 23

Section 32 16 23.10

PORTLAND CEMENT CONCRETE SIDEWALK, SPECIAL

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This work will consist of constructing PORTLAND CEMENT CONCRETE SIDEWALK, SPECIAL, (Curb Ramps for People with Disabilities), at locations shown on the plans and/or as directed by the Commissioner. The sidewalk will be either 5 inches or 8 inches thick, as specified in the plans. The tactile detectable warning surface will not be included in this item, but will be under the items for TACTILE/DETECTABLE WARNING SURFACE TILES.

B. This work must conform to the applicable portions of Section 424 of the Standard Specifications (IDOT) and the Standard Details for Construction of Curb Ramps for People with Disabilities included in the plans and to the applicable portions of the CDOT QC/QA program, which shall take precedence over all other specifications.

1.03 RELATED SECTIONS

1. Section 031000: Concrete Formwork
2. Section 032000: Concrete Reinforcement and Embedded Assemblies
3. Section 033000: Cast-In-Place Concrete
4. Section 312313: Subgrade Preparation.
5. Section 321116: Sub-base Granular Material, Type B.
6. Section 321217: Protective Coat.
7. Section 321621: Concrete Curbs, Gutters and Walks.
8. Section 321726: Tactile-Detectable Warning Surface Tiles

1.04 REFERENCES

A. Illinois Department of Transportation (IDOT) Standard Specifications for Road and Bridge Construction, adopted April 1, 2016, or latest edition.

B. Chicago Department of Transportation Regulations for Openings, Construction, and Repair in the Public Way (including Appendix B – ADA Standards).

C. Americans with Disabilities Act (Title 49 CFR TRANSPORTATION, Part 37.9 STANDARDS FOR ACCESSIBLE TRANSPORTATION FACILITIES).

PART 2 - PRODUCTS

2.01 MATERIALS

A. Portland Cement Concrete must conform to the applicable portions of Section 1020 of the Standard Specifications. Concrete must be Class SI Concrete, compressive strength of 3500 psi at 14 days.

2.02 FORMS

A. The use of steel forms will not be permitted.

PART 3 - EXECUTION

3.01 METHOD OF CONSTRUCTION

A. Conform to requirements of IDOT Standard Specification for Road and Bridge Construction, Section 424.

B. Concrete testing for PORTLAND CEMENT CONCRETE SIDEWALK, SPECIAL must be completed as specified in the standard CDOT QC/QA program which is covered in IDOT's Recurring Special Provision Check Sheet 31.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The Work of PORTLAND CEMENT CONCRETE SIDEWALK, SPECIAL, will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the Work of PORTLAND CEMENT CONCRETE SIDEWALK, SPECIAL, will be included in the contract lump sum price as shown in the Schedule of Prices for CIVIL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 020000

END OF SECTION 32 16 23.10

SECTION 32 17 23
PAVEMENT MARKINGS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes requirements for installing temporary and permanent pavement markings.

1.03 RELATED SECTIONS

A. Section 015526 - Traffic Control and Regulations.

B. Section 321216 – Asphalt Paving

C. Appendix B – CDOT Special Provisions

1.04 REFERENCES

A. CDOT Regulations for Openings, Construction, and Repair in the Public Way (CDOT Specifications), latest edition

B. CDOT Bike Lane Design Guide, latest edition.

C. IDOT Standard Specifications for Road and Bridge Construction (SSRBC), latest edition.

1.05 QUALITY ASSURANCE

A. Conformance with Specifications. Comply with this Section and CDOT Specifications for all work within public right-of-way. In the event that a conflict exists between this Section and the CDOT Specifications, CDOT Specifications govern. Work, which is not within CDOT jurisdiction, must be coordinated with the Commissioner to ensure compliance to all standards and permit requirements.

PART 2 - PRODUCTS

2.01 PAVEMENT MARKINGS

A. Pavement markings on all finished pavements must be the thermoplastic extruded type conforming to the requirements of Section 1095.01 of the SSRBC.

B. Temporary pavement markings must be:

1. Paint or Pavement Marking Tape on milled surfaces, primed surfaces, and binder courses, conforming to Article 1095.02 and 1095.06 of the SSRBC;
2. Pavement marking tape on final surface course, conforming to Article 1095.06 of the SSRBC.

C. Raised reflective pavement markers must conform to the requirements of Section 1096.01 of the SSRBC.

D. Pavement markings for bicycle symbols, bicycle lettering and speed bumps must be pre-cut plastic pavement markings.

E. Curb paint marking must be a yellow color to match Safety Yellow. A draw down must be submitted for approval.

PART 3 - EXECUTION

3.01 GENERAL

A. Notification to CDOT

1. Notify the Commissioner and CDOT for inspection of work requiring CDOT approval forty-eight (48) hours prior to commencing additional work. If CDOT inspectors fail to perform the inspection within forty-eight (48) hours after notification, the Contractor may, after approval of the Commissioner, proceed with subsequent work.

3.02 PAVEMENT MARKINGS

A. Temporary pavement markings are to be provided where existing pavement markings are milled surfaces and on the binder and surface courses. The installation of Temporary Pavement Markings must meet the requirements of Section 703 of the SSRBC, or as directed by the Commissioner.

B. All pavement markings, including thermoplastic lane dividers, etc. removed during construction must be replaced. The installation of Pavement Markings must meet the requirements of Section 780 of the SSRBC, or as directed by the Commissioner.

3.03 TRAFFIC CONTROL

A. The Contractor is responsible for traffic control and the protection of vehicular and pedestrian traffic from the work. For detailed requirements see Section 015526 – Traffic Control.

3.04 RAISED REFLECTIVE PAVEMENT MARKERS

A. All raised reflective pavement markers removed during construction must be replaced. The installation of Raised Reflective Pavement Markers must meet the requirements of Section 781 of the SSRBC, or as directed by the Commissioner.

3.05 PRE-CUT PAVEMENT MARKINGS

A. Installation Requirements:

1. Air Temperature 60o Fahrenheit and rising.
2. Pavement Temperature 70o Fahrenheit and rising.
3. Overnight Temperature 40o Fahrenheit minimum.
4. No rainfall within twenty-four (24) hours preceding placement.
5. Contact cement primer to be allowed to dry before applying marking.
6. Tamp marking three (3) times back and forth for an equivalent of six (6) passes using a tamper cart carrying 200 pounds (lbs.) of weight. Passes are to work any entrapped air from center of marking outward to edges.

3.06 CURB PAINTING

A. Curb painting is to be in accordance with applicable portions of Section 780 of the SSRBC.

1. When directed by the Commissioner the top and face of the curb is to be painted yellow for 15 feet each side of the fire hydrant, except where the 15 foot dimension intersects a crosswalk, driveway or similar feature.
2. Glass beads are NOT required.
3. Painting is to have neat straight edges along back of curb and vertically up the curb face.

3.07 CURB PAINTING REMOVAL

A. Existing curb painting that is not in conformance with the new fire hydrant location is to be removed.

1. The paint is to be removed from the curb by scraping, or mechanical wire brushing.
2. The existing curb markings are to be removed by a method that does not materially damage the surface or texture of the curb surface. Very small particles of tightly adhering existing paint marking may remain in place, if

in the opinion of the Commissioner, complete removal of the paint will result in surface damage.

3. Any damage to the curb caused by the paint removal is to be repaired by methods acceptable to the Commissioner.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The work of PAVEMENT MARKINGS shall not be measured for payment.

4.02 PAYMENT

A. No separate payment shall be made for the work covered in this section. Payment for the Work of PAVEMENT MARKINGS shall be included in the contract lump sum price as shown in the Schedule of Prices for CIVIL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 020000.

TABLE A - STANDARD LETTER & SYMBOL SIZES

Letter or Symbol Type	Large Size – Sq. Ft.	Small Size – Sq. Ft.
"ONLY"	28.8	17.8
Through Arrow	11.5	6.5
Left or Right Arrow	15.6	8.8
Combination Left (Right) and Through Arrow	26.0	14.7
Railroad "R" (6 Ft.)	3.6	-
Railroad "X" (20 Ft.)	54.0	-
Handicap Symbol	4.6	-
Bike Lane Symbol	10.9	-
Bike Lane Arrow Symbol	5.8	-

END OF SECTION 32 17 23

SECTION 32 17 26

LINEAR DETECTABLE WARNING TILES (CAST IRON)

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. DESCRIPTION: Work under this item shall consist of installing cast iron detectable warning tiles on ADA curb ramps in according to the latest Chicago Department of Transportation ADA Standards. Work shall be performed in according to the SECTION 424 of the SSRBC, except as herein modified.

B. Systems must be installed across the entire width of the depressed curb, and per the latest CDOT ADA Standard details.

C. RELATED SECTIONS

1. Section 321623: Portland Cement Concrete Sidewalk, 5-Inch.
2. Section 321623.10: Portland Cement Concrete Sidewalk, Special.

1.03 REFERENCES

A. Illinois Department of Transportation (IDOT) Standard Specifications for Road and Bridge Construction, latest edition.

B. Chicago Department of Transportation Regulations for Openings, Construction, and Repair in the Public Way (including Appendix B – ADA Standards).

C. Americans with Disabilities Act (Title 49 CFR TRANSPORTATION, Part 37.9 STANDARDS FOR ACCESSIBLE TRANSPORTATION FACILITIES, Appendix A, Section 4.29.2 DETECTABLE WARNINGS ON WALKING SURFACES.

PART 2 - PRODUCTS

2.01 MATERIALS

A. MATERIALS: DETECTABLE WARNING TILES SHALL BE CAST GRAY IRON AND SHALL BE PROVIDED BY A MANUFACTURER APPROVED BY THE CITY OF

CHICAGO DEPARTMENT OF TRANSPORTATION. A LIST OF APPROVED MANUFACTURERS OF CAST IRON DETECTABLE WARNING TILES IS AVAILABLE ON THE CITY OF CHICAGO DEPARTMENT OF TRANSPORTATION WEBSITE UNDER CONSTRUCTION GUIDELINES/STANDARDS.

B. THE CAST IRON DETECTABLE WARNING TILES SHALL BE OF UNIFORM QUALITY, FREE FROM SURFACE DEFECTS AND SHALL BE PROVIDED WITH AN UNTREATED, NATURAL SURFACE FINISH AS DIRECTED BY THE COMMISSIONER.

PART 3 - EXECUTION

3.01 INSTALLATION

CONSTRUCTION REQUIREMENTS: THE DETECTABLE WARNING SYSTEM SHALL BE INSTALLED IN FRESH CONCRETE AND SHALL COMPLY WITH THE CITY OF CHICAGO DEPARTMENT OF TRANSPORTATION REGULATIONS FOR OPENINGS, CONSTRUCTION AND REPAIR IN THE PUBLIC WAY, APPENDIX B, ADA STANDARDS. THE EQUIPMENT AND INSTALLATION PROCEDURES SHALL BE ACCORDING TO THE MANUFACTURER'S SPECIFICATIONS. THE CONTRACTOR SHALL INSTALL THE DETECTABLE WARNING SYSTEM FLUSH WITH ADJACENT CONCRETE, AND RESULTING IN A SNUG FIT BETWEEN TILES TO LIMIT WATER INFILTRATION AROUND THE PERIMETER OF THE SYSTEM AND BETWEEN TILES, AS DIRECTED BY THE COMMISSIONER.

QC/QA REQUIREMENTS: A MANUFACTURER'S WRITTEN CERTIFICATION THAT THE MATERIAL COMPLIES WITH these specifications shall be provided to the Commissioner

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The Work of TACTILE/DETECTABLE WARNING SURFACE TILES will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the Work of TACTILE/ DETECTABLE WARNING SURFACE TILES, will

be included in the contract lump sum price as shown in the Schedule of Prices for CIVIL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 020000.

END OF SECTION 32 17 26

SECTION 32 31 13

CHAIN-LINK FENCE AND GATES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This section includes requirements for the installation of chain-link construction fencing of height and length, and at locations shown on the Drawings, specified here, or as directed by the Commissioner.

B. Provide all labor, materials, and tools necessary to complete the Work specified here.

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM), latest edition:

1. ASTM A53 - Pipe, Steel, Black and Hot Dipped, Zinc Coated, Welded and Seamless.
2. ASTM A123 - Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products.
3. ASTM A153 - Zinc Coating (Hot Dip) on Iron and Steel.
4. ASTM A392 - Zinc-Coated Steel Chain-Link Fence Fabric.
5. ASTM A491 - Aluminum-Coated Steel Chain-Link Fence Fabric.
6. ASTM A585 - Standard Practice for Providing High Quality Zinc Coatings (Hot Dip).
7. ASTM F626 - Standard Specifications for Fence Fittings.
8. ASTM F668 - Standard Specification for Poly (Vinyl Chloride) (PVC) and other Organic Polymer-Coated Steel Chain-Link Fence Fabric.

1.04 SUBMITTALS

A. Refer to Book 1 for submittal requirements and procedures for Shop Drawings, Product Data, Records and Samples.

B. Manufacturer’s catalog cuts of all chain-link fence material and hardware, and color sample of vinyl coating for approval of color.

PART 2 - PRODUCTS

2.01 CHAIN LINK FENCE FABRIC AND FABRIC WIRE TIES

A. Fence fabric is to be fabricated from galvanized or aluminum coated steel, or aluminum 6, 8, 10 - gauge wire, interwoven in a 1-1/2-inch, 2-inch square continuous mesh type pattern. The fence fabric must be of top grade material and must not contain any sections with bent or knotted wire, tied wire splices, or other types of repairs. All fence fabric must conform to the requirements of ASTM A392 or ASTM A491.

B. Wire ties used for securing wire fabric to fence posts and rails must be manufactured from galvanized coated steel or aluminum wire. Gauge of wire ties to match wire gauge of fence fabric.

2.02 POSTS, RAILS, GATE FRAMES AND BRACES

A. All posts, rails, and braces are to be fabricated from schedule 40 galvanized steel pipe conforming to ASTM A53.

B. Dimensions and weights:

1. End, corner, pull, and gate posts and braces are to have a nominal diameter of 2.5-inches and weight of 5.79-lbs / ft.
2. Line posts: are to have a nominal diameter of 2-inches and weight of 3.65-lbs / ft.
3. Gate frame: members are to have a nominal diameter of 1.5-inches and weight of 2.72-lbs / ft.
4. Top and bottom rails are to have a nominal diameter of 1.25-inches and weight of 2.27-lbs / ft.

2.03 GATES

A. Swing type gates are to be of height, widths and open and close in the direction shown on the drawings. Gates must be supplied complete with latches and hinges. Gate latches must be of the forked type with integral pad-lock eyes to permit operation from either side of gate.

B. Gate materials and fittings to be supplied by the fence manufacturer.

2.04 HARDWARE AND FITTINGS

A. Hardware and fittings must be manufactured from solid aluminum alloy / aluminum coated steel conforming to ASTM F626, or hot dip galvanized steel conforming to ASTM A153.

B. Fence post top finials must be provided with holes suitable for through passage of top rails.

2.05 TENSION BARS

A. Minimum 1/4 by 3/4 Inch galvanized coated steel, conforming to ASTM A585.

B. One bar for each end and gatepost, and two for each corner and pull post.

2.06 FOOTINGS

A. All fence post footings must be Class SI concrete conforming to SSRBC IDOT specifications and be of size and depth as shown on the drawings.

2.07 DECORATIVE VINYL COATING

A. All fence fabric, support posts, rails, tension bars, gates, gate frames, braces, tension bars, and miscellaneous hardware and fittings specified in paragraphs 2.1 to 2.5 of this section, are to be coated with a 7 mil, minimum thickness, of (select green, black, brown, or custom color) vinyl coating conforming to ASTM F668.

PART 3 - EXECUTION

3.01 POSTS AND RAILS

A. Install line posts at regular intervals of 10 feet apart, unless shown otherwise on the Drawings or directed by the Commissioner.

B. Install corner posts where fence line changes direction by more than 15º; install gate posts on each side of each gate.

C. Install end posts at beginning and end of fence line; install pull posts as needed to keep the fabric taut and as per the manufacturer's recommendations.

D. Set posts in concrete footings, plumb and true to line.

E. Fasten top rail to end, pull, gate, and corner posts. Pass top rail through fittings of line posts.

F. Fasten bottom rail to end, pull, gate, corner, and line posts.

3.02 FOOTINGS

A. Excavate footings with vertical sides to minimize uplift. Dispose of excavated material off site.

B. Rod and compact concrete around posts. Slope top of footings above level of adjacent grade and trowel finish.

C. Footing Sizes:

1. Minimum diameter of 6-inches plus the outside dimension of the post.
2. Set corner, end, pull, and gate posts 42-inches into concrete.
3. Set line posts 36-inches into concrete.
4. Total depth of concrete shall be 6-Inches greater than required for post embedment.

D. Footings are to set for forty-eight (48) hours before rails are erected or fabric attached or stretched.

3.03 FENCE FABRIC

A. Place fabric on the street-side of posts and stretch to avoid bulging or buckling.

B. Fasten at line posts, top and bottom rails with wire ties. Space wire ties not more than 15-Inches apart on line posts and not more than 24-inches apart on top and bottom rails.

C. Fasten at end, pull, gate and corner posts at intervals not exceeding 15-Inches using flat or beveled galvanized coated steel bands, with 7-mil thick vinyl coating in color to match fence fabric, and secure with 5/16-inch by 1 ¼-inch galvanized coated steel carriage bolts and nuts.

D. Cover gate frames with fence fabric, attached securely to frame with chain-link metal fabric ties with a 15-inch maximum spacing.

E. Make wire tie connections opposite the side the fabric is on.

F. Fabric at bottom of fence to have twisted ends. Fabric at top of fence to have knuckled selvage ends.

3.04 GATES

A. Install gates plumb, level, and secure for full opening without interference.

B. Install ground-set items in concrete for anchorage.

C. Adjust hardware for smooth operation and lubricate where necessary.

D. Install gates according to manufacturer's instructions, plumb, level, and secure.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The work of CHAIN-LINK FENCE AND GATES shall not be measured for payment.

4.02 PAYMENT

A. No separate payment shall be made for the work covered in this section. Payment for the Work of CHAIN-LINK FENCE AND GATES shall be included in the contract lump sum price as shown in the Schedule of Prices for CIVIL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 020000.

END OF SECTION 32 31 13

SECTION 32 93 00

PLANTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SECTION INCLUDES

A. Provide Materials and labor for the installation of landscape plantings, including maintenance and supplemental watering as indicated on the drawings and specified herein for:

1. Trees
2. Topsoil and amendment
3. Fertilizers and mulches
4. Stakes and guys

1.3 SUBMITTALS

A. Product certificates signed by manufacturers certifying that their products comply with specified requirements.

1. Manufacturer's certified analysis for standard products.
2. Label data substantiating that plants, trees, shrubs, and planting materials comply with specified requirements.

B. Qualification data for firms and persons specified in the "Quality Assurance" Article to demonstrate their capabilities and experience. Include a list of five completed projects of similar scope and dollar value. Provide project references including project names and addresses, names and addresses of Landscape Architects and owners, and other information specified.

C. Material test reports from qualified independent testing agency indicating and interpreting test results relative to compliance of the following materials with requirements indicated.

1. Analysis of existing surface soil, topsoil.
2. Analysis of imported topsoil.

D. Planting schedule indicating anticipated dates and locations for each type of planting. Submit list of sources for plant material to be provided.

E. Maintenance instructions recommending procedures to be established by Owner for maintenance of landscaping during an entire year. Submit before expiration of required maintenance periods.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced Installer who has completed landscaping work similar in material, design, and extent to that indicated for this Project and with a record of successful landscape establishment. Installer shall be an approved Landscape Contractor with a minimum of five (5) years' experience on comparable projects. Use experienced crews:

1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on the Project site during times that landscaping is in progress.

B. Testing Agency Qualifications: To qualify for acceptance, an independent testing agency must demonstrate to Landscape Architect's satisfaction, based on evaluation of agency-submitted criteria conforming to ASTM E 699, that it has the experience and capability to satisfactorily conduct the testing indicated without delaying the work.

C. Provide quality, size, genus, species, and variety of trees and shrubs indicated, complying with applicable requirements of ANSI Z60.1 "American Standard for Nursery Stock", latest edition.

1. Plants shall meet all requirements of federal, state, and local law with respect to plant type, labeling, nursery or plant inspection, disease, insect and other pest infestation, and any other requirements.
2. Plants shall be high quality nursery stock.
3. Substandard "B-grade" or "Park-grade" plants are not acceptable.
4. Field-collected plants are not acceptable, even if they have been subsequently planted in the ground in a nursery or planted in a container.
5. Plants shall be in a healthy, vigorous condition, free of dead or broken branches, scars that are not completely healed, frost cracks, disfiguring knots, broken or abraded bark, redundant leaders or branches, or aberrations of any kind. Plants shall not have multiple leaders, unless this is the natural form.
6. Plants shall have full, even, well-developed branching and a dense, fibrous, and vigorous root system.
7. Container plants shall have been established for a minimum of one full growing season in their containers before installation.
8. Bare root plants are not acceptable.

D. Tree Selection:

1. At the time of award, the contractor shall identify the trees for the Project by name and location of tree nursery.
2. Confirmation by the tree nursery representative, in writing, that the trees specified will be available at the specified size, quality, and quantity at the time of the Project tree installation.
3. The Contractor shall make tree nursery aware of the project name.

4. Specified trees, shrubs, and groundcovers shall be located in northeastern Illinois nurseries (nurseries in zones 4 or 5 only), or nurseries approved by the Landscape Architect. The Contractor shall review and pre-tag the trees prior to inspection by the Landscape Architect. Locating specified and/or substitute trees shall not delay the project schedule, and shall not be considered an additional service and/or fee to the contract.

E. Topsoil Analysis: Furnish a soil analysis made by a qualified independent soil-testing agency stating percentages of organic matter, inorganic matter (silt, clay, and sand), deleterious material, pH, and mineral and plant-nutrient content of topsoil.

1. Report suitability of topsoil for growth of applicable planting material. State recommended quantities of nitrogen, phosphorus, and potash nutrients and any limestone, aluminum sulfate, or other soil amendments to be added to produce satisfactory topsoil.

F. Measurements: Measure trees and shrubs according to ANSI Z60.1 with branches and trunks or canes in their normal position. Do not prune to obtain required sizes. Take caliper measurements 6 inches (150 mm) above ground for trees up to 4-inch (100-mm) caliper size, and 12 inches (300 mm) above ground for larger sizes. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip-to-tip.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in containers showing weight, analysis, and name of manufacturer. Protect materials from deterioration during delivery and while stored at site.

B. Trees and Shrubs: Deliver freshly dug trees and shrubs. Do not prune before delivery, except as approved by Landscape Architect. Protect bark, branches, and root systems from sun scald, drying, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy natural shape. Provide protective covering during delivery. Do not drop trees and shrubs during delivery.

C. Handle balled and burlapped stock by the root ball.

D. Deliver trees, shrubs, ground covers, and plants after preparations for planting have been completed and install immediately. If planting is delayed more than 6 hours after delivery, set planting materials in shade, protect from weather and mechanical damage, and keep roots moist.

1. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material. Do not set plant root ball directly on asphalt paving. Provide insulating material, which is larger than the root ball area, to guard against paving heat radiation. Cover ball with protection material as mentioned above. The trees shall not be set in vehicular or pedestrian traffic areas.

2. Do not remove container-grown stock from containers before time of planting.
3. Water root systems of trees and shrubs stored on site with a fine-mist spray. Water as often as necessary to maintain root systems in a moist condition.

1.6 JOB CONDITIONS

A. Utilities: Determine location of above grade and underground utilities and perform work in a manner which will avoid damage. Hand excavate, as required. Maintain grade stakes until removal is mutually agreed upon by parties concerned.

B. Excavation: When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, or obstructions, notify Landscape Architect before planting.

1.7 COORDINATION AND SCHEDULING

A. Coordinate installation of planting materials during normal planting seasons for each type of plant material required.

1. Deciduous Trees and Shrubs: Workable ground to June 1st, and September 1st to December 1st, except as noted on plans.
2. Spring Only Materials: Plant Spring-Only plants in the spring (workable ground to June 1st) and only in a dormant state unless otherwise accepted by the Landscape Architect.

B. Plants installed outside of dates specified shall not be accepted, unless approved by the Landscape Architect.

1.8 WARRANTY

A. General

1. In lieu of the provisions as to warranties in the general conditions, the Contractor shall warranty and maintain plant material for a period of one (1) year from the date of the Final Acceptance of the plant material. If any plant material install by the Contractor is not in a healthy and thriving condition due to, but not limited to: improper handling or planting; improper after care including trimming, watering, weeding, cultivating, etc.; or from shock of transplanting, the Contractor shall upon due notice, remove said plant(s), dispose of it/them off the project property, and furnish and plant a new plant of the same type, size and quality, at no cost to the Owner. Both the final acceptance of the plant material and the inspection one (1) year later to satisfy the warranty, shall be done when the plant material is in full leaf. Once the plant material has been tagged in the nursery by the Contractor and the Landscape Architect or his/her designee, the Contractor accepts that each and every plant is in a healthy and thriving condition and assumes the responsibility of each plant. The Contractor shall assume the responsibility for supplying and replacing all plants not in a healthy and thriving condition at the end of the warranty period.
2. Warrant all plant material to be true to botanical name and of the specified size.

3. After receiving a Notice of Final Acceptance, all lawn and plant materials shall be warranted against defects including death, disease or infestation, unsatisfactory growth and improper maintenance for the one year Warranty Maintenance Period following project acceptance.
4. The installation contractor shall not be responsible for defects resulting from Owner negligence, or damage resulting from unusual phenomena or incidents beyond the installer's control. Actions that may be helpful due to unusual weather conditions must be presented to the Landscape Architect at or before the time of occurrence and will be negotiated with the Landscape Architect as additional services.

B. Replacements:

1. During the warranty period, replace, at no additional expense to the Owner, plant materials that are dead or that are, in the opinion of the Landscape Architect, in an unhealthy or unsightly condition, or that have lost their natural shape due to dead branches. Rejected plant materials shall be removed from the site and legally disposed of at no additional expense to the Owner.
2. Replacement plants and planting operations shall be in accordance with the original specifications. Replacements shall be made as soon as possible. Fully restore areas damaged by replacement operations to their original and specified condition.
3. All material which was replaced at the end of the one (1) year warranty maintenance period shall be subject to an extended one (1) year warranty and maintenance period. At the end of the extended warranty and maintenance period, any of the replaced materials which are not in an acceptable condition, as herein before stated, shall be replaced. Once these replacements are made and approved by the Landscape Architect, the Contractor's obligation under this contract ends

1.9 TREE AND SHRUB MAINTENANCE

A. Maintain trees and shrubs by pruning, cultivating, watering, weeding, fertilizing, restoring planting saucers, tightening and repairing stakes and guy supports, and resetting to proper grades or vertical position, as required to establish healthy, viable plantings. Spray as required to keep trees and shrubs free of insects and disease. Maintain trees and shrubs for the following period:

1. Maintenance Period: 12 months following Final Acceptance

PART 2 - PRODUCTS

2.1 TREE AND SHRUB MATERIAL

A. General: Furnish nursery-grown trees and shrubs conforming to ANSI Z60.1, with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully-branched, healthy, vigorous stock free of disease, insects, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.

B. Grade: Provide trees and shrubs of sizes and grades conforming to ANSI Z60.1 for type of trees and shrubs required. Trees and shrubs of a larger size may be used if

acceptable to Landscape Architect, with a proportionate increase in size of roots or balls.

C. Label each tree and shrub with securely attached, waterproof tag bearing legible designation of botanical and common name.

D. Tree Root Ball Sizes: The minimum acceptable tree root ball sizes shall be (per ANSI Z60.1).

Tree Trunk Caliper Size	Root Ball Diameter	Root Ball Depth
4″	42″	26″
3-1/2″	38″	23″
3″	32″	20″
2-1/2″	28″	17″

If the Landscape Architect finds that, after any of the trees have been dug and balled and burlapped, that the root balls do not meet the above size requirements, the Landscape Architect may reject any plants that do not meet these qualifications. The Contractor shall be responsible to replace these trees, in kind, at no additional cost and with no delay to the Project schedule.

2.2 TREE AND SHRUB MATERIAL

A. Shade Trees: Single-stem trees with straight trunk, well-balanced crown, and intact leader, of height and caliper indicated, conforming to ANSI Z60.1 for type of trees required

1. Branching Height: 1/3 of tree height.

B. Provide balled and burlapped trees.

2.3 TOPSOIL

A. Topsoil: ASTM D 5268, pH range of 5.5 to 7, 4 percent organic material minimum, free of stones 1 inch (25 mm) or larger in any dimension, and other extraneous materials harmful to plant growth. All topsoil shall be pulverized.

1. Topsoil Source: Verify suitability of surface soil to produce topsoil meeting requirements and amend as required. Supplement with imported topsoil when quantities are insufficient. Clean topsoil of roots, plants, sods, stones, clay lumps, and other extraneous materials harmful to plant growth.
2. Topsoil Source: Import topsoil from off-site sources. Obtain topsoil from naturally well-drained sites where topsoil occurs at least 4 inches (100 mm) deep; do not obtain from bogs, marshes, or golf courses.
3. Topsoil Source: Amend existing surface soil to produce topsoil. Supplement with imported topsoil when required.

2.4 SOIL AMENDMENTS

A. Lime: ASTM C 602, Class T, agricultural limestone containing a minimum 80 percent calcium carbonate equivalent, with a minimum 99 percent passing a No. 8 (2.36 mm) sieve and a minimum 75 percent passing a No. 60 (250 micrometer) sieve.

1. Provide lime in the form of dolomitic limestone.

B. Sand: Clean, washed, natural or manufactured sand, free of toxic materials

C. Aluminum Sulfate: Commercial grade, unadulterated.

D. Perlite: Horticultural perlite, soil amendment grade.

E. Peat Humus: Finely divided or granular texture, with a pH range of 6 to 7.5, composed of partially decomposed moss peat (other than sphagnum), peat humus, or reed-sedge peat

F. Water: Potable

2.5 FERTILIZER

A. Bonemeal: Commercial, raw, finely ground; minimum of 4 percent nitrogen and 20 percent phosphoric acid.

B. Superphosphate: Commercial, phosphate mixture, soluble; minimum of 20 percent available phosphoric acid.

C. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea-form, phosphorous, and potassium in the following composition:

1. Composition: 1 lb per 1000 sq. ft. (0.5 kg per 100 sq. m) of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight
2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency

D. Slow-Release Fertilizer: Granular fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition.

1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.

2.6 MULCHES

A. Organic Mulch: Organic mulch, free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:

1. Type: Shredded hardwood bark mulch, dark brown color for trees and shrubs.
2. Type: Fine pine bark fines mulch created from pine bark, graded and screened to maximum ¾” size for groundcover and perennial beds

2.7 STAKES AND GUYS

A. Upright and Guy Stakes: Rough-sawn, sound, new hardwood, redwood, or pressure-preservative-treated softwood, free of knots, holes, cross grain, and other defects, 2 by 2 inches (50 by 50 mm) by length indicated, pointed at one end.

B. Guy and Tie Wire: ASTM A 641 (ASTM A 641M), Class 1, galvanized-steel wire, 2-strand, twisted, 0.106 inch (2.7 mm) in diameter.

C. Guy Cable: 5-strand, 3/16-inch (4.8-mm) diameter, galvanized-steel cable, with zinc-coated turn buckles, 3-inch- (75-mm-) long minimum, with two 3/8-inch- (10-mm-) galvanized eyebolts.

D. Hose Chafing Guard: Reinforced rubber or plastic hose at least 1/2 inch (13 mm) in diameter, black, cut to lengths required to protect tree trunks from damage.

E. Flags: Standard surveyor's plastic flagging tape, white, 6 inches (150 mm) long.

2.8 MISCELLANEOUS MATERIALS

A. Anti-desiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees and shrubs. Deliver in original, sealed, and fully labeled containers and mix according to manufacturer's instructions.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive landscaping for compliance with requirements and for conditions affecting performance of work of this Section. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Verify location of underground utilities with appropriate sources prior to construction. Contact DIGGER (City of Chicago) or JULIE (outside Chicago city limits) at least 48 hours before commencing with construction operations. Repair damaged utilities.

C. Conflicts with utilities shall be called to the Landscape Architect's attention before proceeding with work. Alternate locations may be designated by Landscape Architect.

3.2 PREPARATION

A. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, and secure Landscape Architect's acceptance before the start of planting work. Make minor adjustments as may be required.

3.3 PLANTING SOIL PREPARATION

A. Before mixing, clean topsoil of roots, plants, sods, stones, clay lumps, and other extraneous materials harmful to plant growth.

B. Mix soil amendments and fertilizers with topsoil as per soil laboratory recommendations. Delay mixing fertilizer if planting does not follow placing of planting soil within a few days.

C. Planting Soil Mix:

1. For tree pit or trench backfill, mix planting soil before backfilling and stockpile at site.
2. Sand: Clean, sharp, well-graded, coarse sand passing ¼" mesh screen, free of foreign and organic matter, with a pH of 6.0 to 7.0.

3.4 EXCAVATION FOR TREES AND SHRUBS

A. Pits and Trenches: Excavate with vertical sides and with bottom of excavation slightly raised at center to assist drainage. Loosen hard subsoil in bottom of excavation.

1. Balled and Burlapped Trees and Shrubs: Excavate approximately 1-1/2 times as wide as ball diameter and equal to ball depth, or as indicated on the plans, plus the following setting layer depth:

a. Setting Layer: Allow 9 inches (225 mm) of planting soil

B. Dispose of subsoil removed from landscape excavations. Do not mix with planting soil or use as backfill.

C. Obstructions: Notify Landscape Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.

1. Hardpan Layer: Drill 6-inch- (150-mm-) diameter holes into free-draining strata or to a depth of 10 feet (3 m), whichever is less, and backfill with free-draining material.

D. Drainage: Notify Landscape Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub pits.

E. Fill excavations with water and allow to percolate out, before placing setting layer and positioning trees and shrubs

3.5 PLANTING TREES AND SHRUBS

A. Set balled and burlapped stock plumb and in center of pit or trench with top of ball raised above adjacent finish grades as indicated.

1. Place stock on setting layer of compacted planting soil.
2. Remove burlap and wire baskets from tops of balls and partially from sides, but do not remove from under balls. Remove pallets, if any, before setting. Do not use planting stock if ball is cracked or broken before or during planting operation.
3. Place backfill around ball in layers, tamping to settle backfill and eliminate voids and air pockets. When pit is approximately 1/2 backfilled, water

thoroughly before placing remainder of backfill. Repeat watering until no more is absorbed. Water again after placing and tamping final layer of backfill.

B. Dish and tamp top of backfill to form a 3-inch- (75-mm-) high mound around the rim of the pit. Do not cover top of root ball with backfill.

3.6 TREE AND SHRUB PRUNING

A. Prune, thin, and shape trees and shrubs as directed by Landscape Architect

3.7 TREE AND SHRUB GUYING AND STAKING

A. Upright Staking and Tying: Stake trees of 2- through 5-inch (50- through 125-mm) caliper. Stake trees of less than 2-inch (50-mm) caliper only as required to prevent wind tip-out. Use a minimum of 2 stakes of length required to penetrate at least 18 inches (450 mm) below bottom of backfilled excavation and to extend at least 72 inches (1800 mm) above grade. Set vertical stakes and space to avoid penetrating balls or root masses. Support trees with 2 strands of tie wire encased in hose sections at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.

B. Guying and Staking: Guy and stake trees exceeding 14 feet (4.2 m) and more than 3-inch (75-mm) caliper unless otherwise indicated. Securely attach no fewer than 3 guys to stakes 30 inches (760 mm) long, driven to grade. Attach flags to each guy wire, 30 inches (760 mm) above finish grade.

C. Provide guying and staking only if tree fail to remain plumb on their own.

3.8 MULCHING

A. Mulch backfilled surfaces of pits, trenches, planted areas, and other areas indicated.

B. Organic Mulch: Apply the following average thickness of organic mulch and finish level with adjacent finish grades. Do not place mulch against trunks or stems.

1. Thickness: 3 inches (75 mm).

3.9 INSTALLATION OF MISCELLANEOUS MATERIALS

A. Apply antidesiccant using power spray to provide an adequate film over trunks, branches, stems, twigs, and foliage.

1. When deciduous trees or shrubs are moved in full-leaf, spray with antidesiccant at nursery before moving and again 2 weeks after planting.

3.10 CLEANUP AND PROTECTION

A. During landscaping, keep pavements clean and work area in an orderly condition.

B. Protect landscaping from damage due to landscape operations, operations by other contractors and trades, and trespassers. Maintain protection during installation and

maintenance periods. Treat, repair, or replace damaged landscape work as directed.

3.11 DISPOSAL OF SURPLUS WASTE MATERIALS

A. Disposal: Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of it off the Owner's property.

3.12 MAINTENANCE

A. Maintenance Period: Perform landscape maintenance, as specified hereunder, for the following period.

1. Initial Maintenance: The Contractor is responsible for maintenance of all landscape areas until it has been accepted by the Landscape Architect. Begin maintenance immediately upon delivery to the site and as each plant and each portion is planted.
2. Maintenance Period: 12 months following Final Acceptance.

B. Work Subject to Maintenance: The work installed under this contract for the entire site, including parkways.

C. Maintenance of Plant Materials: Maintain all plantings in a healthy and flourishing condition. Maintenance of new planting consists of pruning, watering (rainfall shall be supplemented with Contractor watering operations for a total rate of one inch per week during the growing seasons), cultivating, replanting, weeding, mulching, tightening and repairing of guys (if used), restore or replace damaged tree trunk wrap (if used), cleaning, edging, and furnishing and applying sprays as are necessary to keep the plants free of insects and disease.

PART 4 - EXECUTION

4.1 MEASUREMENT AND PAYMENT

A. The work of PLANTINGS shall not be measured for payment.

4.2 PAYMENT

A. No separate payment shall be made for the work covered in this section. Payment for the Work of PLANTINGS shall be included in the contract lump sum price as shown in the Schedule of Prices for Civil Work.

4.3 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 020000

END OF SECTION 32 93 00

SECTION 33 01 10.10

CATCH BASIN OR MANHOLE TO BE CLEANED

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This work will consist of cleaning and proper disposal of any accumulation of silt, debris, and foreign matter of any kind from catch basins, or manholes, which are located outside the proposed base course area, such as an existing street return to be resurfaced or a parkway to be graded.

1.03 RELATED SECTIONS

1. Section 013236: Televised Inspection of Sewer Mains
2. Section 015526: Traffic Control
3. Section 321216: Asphalt Paving.
4. Section 330514: Water Valve Box or Buffalo Box To Be Adjusted.

1.04 REFERENCES

A. Illinois Department of Transportation (IDOT) Standard Specifications for Road and Bridge Construction, Adopted April 1, 2016, or latest edition.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01 The cleaning must be done after the placing of the HMA overlay material.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The Work of CATCH BASIN OR MANHOLE TO BE CLEANED will not be measured for payment.

4.02 PAYMENT

B. No separate payment will be made for the work covered in this section. Payment for the Work of CATCH BASIN OR MANHOLE TO BE CLEANED will be included in the contract lump sum price as shown in the Schedule of Prices for CIVIL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 020000.

END OF SECTION 33 01 10.10

SECTION 33 01 30

CLEANING AND LINING SEWER MAINS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This section includes the requirement for cleaning and cured-in-place lining of existing sewer main, lateral piping and tee connections, and by-pass pumping operations necessary to perform lining of existing sewers.

1.03 RELATED SECTIONS

A. City of Chicago Department of Water Management - Sewer Permit Requirements and Fees, latest edition

B. Book 3 - Technical Specifications

a. Section 015526 –Traffic Control
b. Section 013236 – Televised Inspection of Sewer Mains.
c. Section 333913 – Sewer Manholes, Catch Basins, Inlets and Special Structures
d. Section 312310 – Excavation, Trenching and Backfilling (Utilities)

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM), latest edition:

1. ASTM D638: Standard Test Method for Tensile Properties of Plastics.
2. ASTM D790: Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
3. ASTM D2990: Tensile, Compressive, and Flexural Creep and Creep Rupture of Plastics.
4. ASTM D5813: Cured-In-Place Thermosetting Resin Sewer Pipe.
5. ASTM F1216: Rehabilitation of Existing Pipelines and Conduits by the
6. Inversion and Curing of a Resin-Impregnated Tube.

1.05 SUBMITTALS

A. Submit the following information to the Commissioner for review in accordance with Book 1 - Shop Drawings, Product Data, Records and Samples.

B. Product Data:

1. Detailed information regarding materials, chemical charts, and catalog data on all materials proposed for lining sewer mains and laterals at least 28 days before it is to be used for lining the pipeline.

C. Detail Information:

1. Design calculations of proposed sewer lining for each installation.
2. Wet out procedures for liner prior to installation.
3. Equipment, methods, flushing, reinstatement of services, and testing, and operations schedules proposed for cleaning and lining work.
4. Locations for the access openings for cleaning and lining prior to construction and after having reviewed these locations in the field.

D. Samples: Contractor is responsible at his own expense for taking, and shipping of all samples of materials used for lining. For each inversion (or insertion), two cured-in-place samples must be taken from a section of the cured pipe at an intermediate manhole or from a coupon cut from a lateral connection. Samples must be clearly identified with the date, time and location of the inversion (or insertion). The samples must be turned over to the onsite Engineer immediately after removal.

1. One sample will be retained by the Department; the other sample must be tested in accordance with current ASTM specifications for cured-in-place pipe. Testing must be performed by the Contractor through a certified independent testing laboratory.
2. Test results must be submitted to the Department no later than 30 days after sampling and will be certified and stamped by a licensed Professional Engineer registered in the State of Illinois. The Department will reject all inversions (or insertions) not meeting the ASTM specifications.

1.06 QUALITY ASSURANCE

A. Perform all work under the constant supervision of a qualified foreman with at least three years of experience within the last five years in this type of work. Submit a record of experience of proposed foreman to the Commissioner in accordance with Book 1 - Shop Drawings, Product Data, Records and Samples prior to the start of work. The record is to include location and description of work, supervisor’s and company’s name, and dates the experience took place.

B. Provide minimum interference with the operation and maintenance of all interconnected sewer systems.

C. Televised Inspection:

1. Contractor must televise and record the interior of all pipelines to be rehabilitated in accordance with Section 013236 – Televised Inspection of Sewer Mains at the following times:

    a. Following cleaning of pipeline: In the presence of the Commissioner's representative inspect for satisfactory cleaning, defects in pipeline and service lateral locations and condition and report findings to the Commissioner. The Commissioner is to determine whether repair or replacement is required.
    b. If the installation of tee-liner for lateral sewer connections or lateral sewer point repair is required by the Commissioner. Contractor must inspect for satisfactory installation of repair.
    c. Following applications of cured-in-place lining Contractor must again televise the interior of the sewer to inspect for satisfactory application of cured-in-place lining and restoration of laterals.

2. Provide two labeled copies of all televised inspections in DVD format to the Commissioner within five (5) days of taping.

D. Cured-In-Place Lining:

1. The Commissioner's inspection and acceptance of cleaning is required before cured-in-place lining of the pipeline sections.
2. All lining thicknesses and tolerances must be in accordance with the latest revision of ASTM F1216 and the approved design calculations.
3. The Commissioner's approval is required for acceptance, after cured-in-place lining work is completed for the pipeline sections.

1.07 DELIVERY, STORAGE AND HANDLING:

A. All excavated materials and equipment to be incorporated in the work must be placed so as not to injure any part of the work or existing facilities and so that free access can be had at all times to all parts of the work and to all public utility installations in the vicinity of the work. Excavated material is not to be stockpiled on the work site overnight. Materials and equipment must be kept neatly piled and compactly stored in such locations to avoid inconvenience to public travel and adjoining owners, tenants and occupants.

1.08 PROJECT / SITE CONDITIONS:

A. Environmental Requirements:

1. Do not perform work during unsuitable weather conditions including cold weather temperatures below 400 Fahrenheit that may affect the lining process.
2. The Contractor must clarify discharge water from the cleaning process by separating the solid deposits removed from the sewer main. The clarified water is to be disposed of into existing sanitary or combined sewer manholes adjacent to the access point at the discharge location. The roadway and

adjacent areas should be kept free of standing water at all times. The Contractor is to submit a diagram of the proposed method of clarifying the water and associated discharge system to the Commissioner for review and approval.

3. Solid deposits removed from the interior of the main are to be collected and disposed of in a legal manner by the Contractor.

B. Existing Conditions:

1. Existing pavement and base pavements may be cut no larger than necessary to provide working space for access pits and installation of appurtenances. Pavement removal is to be in accordance with Section 312310 – Excavation, Trenching and Backfilling (Utilities).
2. All field measurements will be the responsibility of the Contractor.
3. Traffic control is to be in accordance with Section 015526 – Traffic Control – the maximum to be closed is one lane.

1.09 SEQUENCING AND SCHEDULING

A. All sequencing and scheduling of the work will be the responsibility of the Contractor. The Contractor will be required to submit a detailed schedule and work sequence plan to the Commissioner for review in accordance with Book 1 - Shop Drawings, Product Data, Records and Samples prior to beginning any work. The review of this schedule and sequencing plan are for record purposes only and does not constitute acceptance of any means or methods of Construction by the Contractor.

1.10 WARRANTY

A. The Contractor must warrant the work in its entirety for a period of five (5) years. The warranty period must begin at final completion of the project.

PART 2 - PRODUCTS

2.01 MATERIALS

A. General Description: A liner to be installed in an existing sewer using resin-impregnated flexible felt tubes. The liner is to be inverted into the existing sewer utilizing a vertical inversion standpipe and hydrostatic head. Curing is to be accomplished by circulating hot water or any other approved methods suitable to cure the resin into a hard impermeable pipe (sewer liner). When cured, the liner is to extend over the length of the inversion as a continuous tight fitting watertight pipe-within-a-pipe.

B. General Corrosion Requirements: The finished liner must be fabricated from materials which are chemically resistant to withstand exposure to domestic sewage when cured.

C. Materials: The liner tube must be fabricated to a size that when installed will neatly fit the internal circumference of the sewer specified by the City. Allowance must be made for circumferential stretching during insertion. Unless otherwise specified, the Contractor must furnish a general purpose unsaturated polyester resin or epoxy vinyl ester resin or an equally compatible resin meeting the requirements of this section. The catalyst system must be compatible with the process being utilized and it must provide the cured physical strengths specified herein.

D. Physical Strength: The cured sewer liner must conform to the minimum structural standards, as listed below:

Cured Sewer Liner	Standard	Results
Test Method for Tensile Properties of Plastics	ASTM D-638	2,500 psi
Test Method for Flexural Properties of Plastics (Flexural Strength)	ASTM D-790	4,500 psi
Test Method for Flexural Properties of Plastics (Flexural Modules of Elasticity)	ASTM D-790	250,000 psi

E. .Liner Thickness: The liner for the rehabilitated sewer must be designed in accordance with ASTM F1216 using the following parameters.

1. The sewer to be rehabilitated will be considered fully deteriorated.
2. The rehabilitated sewer will be subject to an earth load of 120 pounds per cubic foot.
3. Applicable live load conditions will be considered using A.A.S.H.T.O. HS-20 highway loads.
4. A value of two (2) will be used for the Factor of Safety.
5. The factor for the ovality of the existing sewer is to be determined using the videotape or videodisc of the televised sewer provided by the Department.
6. For bid purposes assume the average out of roundness of pipe to be lined is 5%.
7. When the crown of the sewer to be rehabilitated is 7 feet of less below the surface grade, the soil modulus value will be 700 psi. When the crown of the sewer to be rehabilitated is more than 7 feet below the surface grade, the soil modulus value will be 1,000 psi. For bid purposes assume the average cover over the pipe to be lined is between five (5) feet and eight (8) feet
8. The maximum creep retention factor will be 50%.
9. Ground water depth 10 foot below the surface grade.

F. Lateral and Tee Liner. The liner materials must provide the flexibility to line 45 to 90 degrees bends and produce a smooth inside radius.

2.02 EQUIPMENT

A. Cleaning

1. Sewer mains must be cleaned using a combination of flushing and one or more of the following cable-attached devices, including bucket machines, hydraulic-jet cleaning, rodding machines, and vacuum machines. Other types of cleaning may be utilized by the Contractor if they are capable of producing the specified results and are approved by the Commissioner.
2. The cleaning equipment must be capable of removing all dirt, grease, rocks, bricks, tree roots, mineral deposits, and other deleterious materials and obstructions from the main sewers and manholes.
3. The type of equipment and the method to be used must be based on the condition of the sewer, lateral sewer, or connection to the existing sewer at the time work commences without causing damage to the piping. The selection of equipment must produce the results specified and will be at the Contractor's discretion, subject to the approval of the Commissioner.

B. Bypass Piping

1. The Contractor will be required to supply continuous service to both commercial and residential customers at all times during both the cleaning and lining process when called for on the drawings, specified, or when directed by the Commissioner. All cleaning methods, even those requiring short shutdowns will be required to have a bypass piping system in place. There will be no additional compensation to the Contractor for protecting any bypass piping system from weather, accident or vandalism.

2.03 SOURCE QUALITY CONTROL

A. All materials provided and work performed will be subject to inspection The Contractor must provide, without additional cost to the DWM, samples and reasonable assistance for the inspection of materials and workmanship. The minimum amount of inspection or verification required will be as outlined in ASTM F1215.

PART 3 - EXECUTION

3.01 EXAMINATION AND INSPECTION

A. The entire procedure for cleaning the pipeline and the application of the cured-in-place lining will be subject to continuous inspection by the Commissioner, but the inspection does not relieve the Contractor of the responsibility to provide material and perform work in accordance with this specification. The guarantee period must be five (5) years from the date of final completion. Any repair of defective lining will be at the discretion of the Commissioner and the cost to make such repairs is to be borne by the Contractor.

3.02 PREPARATION

A. Cleaning

1. The Contractor must clean all sewers, lateral and tee connections as required for liner installation. For sewer cleaning, all sludge, dirt, sand, rock, grease, and other solid or semi-solid material existing or resulting from the cleaning operation must be removed at the downstream manhole of the main sewer section being cleaned. The Contractor must not pass material from one main sewer section to another main sewer section.
2. For sewer cleaning, whenever hydraulic cleaning equipment is used, a suitable weir or dam must be constructed in the downstream manhole of the main sewer section from which material is being removed that traps all solids for removal from the sewer. Whenever a bucket machine is used, a suitable container must be provided to receive the materials dumped from the bucket machine.
3. In the event of a rain storm causing debris to wash into a previously cleaned main sewer section/lateral connection, the Contractor must ensure that such main sewer sections/lateral connections are cleaned again prior to the installation of the liner. The Contractor is responsible at the final inspection for ensuring that the entire job is acceptable to the Commissioner.
4. The Department retains the right to determine the acceptance or rejection of all work according to the terms of these Special Provisions. In the event of a rejection of the completed work, corrective action must be initiated within 48 hours of a notice of rejection.

B. ROOT REMOVAL

1. Roots must be removed during the cleaning operation prior to the installation of the liner in those main sewer sections and lateral connections where root intrusion is a problem. All Contractor costs for root removal will be considered incidental to the appropriate bid items for cleaning and no separate payment will be made.

C. CUTTING OF PROTRUDING LATERAL SEWER CONNECTIONS

1. The Contractor must cut and remove protruding private drain lateral connections as ordered by the Commissioner. The work must be accomplished without open excavation by use of cutters inserted into the sewer and operated from a remote surface location.

D. DISPOSAL OF MATERIALS REMOVED

1. All solids or semi-solids resulting from the cleaning and/or repair operations must be removed from the site by the Contractor on a daily basis and transported for disposal in an approved dump location conforming to all current government regulations.
2. The Contractor must not deposit or accumulate debris in main sewer sections.
3. No debris or dump boxes will remain on the public way outside of working hours unless a prior written request is submitted and approved in writing by the Commissioner.

E. PROTECTION DURING CLEANING OPERATIONS

1. Satisfactory precautions must be taken to protect the main sewers and sewer manholes from damage that might be caused by the improper use of cleaning equipment. Whenever hydraulically propelled cleaning tools, which depend on water pressure, or any tools which retards the flow of water in the main sewers is used, precautions must be taken to ensure that the water pressure created does not cause any damage or flooding to any public or private property served by the main sewer section being cleaned.
2. The flow of waste water in the main sewers will be utilized to operate hydraulic cleaning devices whenever possible. When it is necessary to use additional water from other sources to avoid delay in normal work procedures, the water will be conserved and not used unnecessarily. Fire hydrants must not be obstructed by the Contractor's operation.
3. The Contractor is responsible for the costs of restoring all damage to public and private property as a result of all cleaning operations.

F. PROTECTION DURING REHABILITATION OPERATIONS

1. Satisfactory precautions must be taken to protect the main sewers, sewer manholes and lateral connections from damage that might be inflicted by the improper use of rehabilitation equipment. The Contractor must use care to prevent damage to portions of the sewers, sewer structures and lateral connection which are to remain in place. All repairs outside of the limits of removal or order by the Commissioner and which are damaged by the Contractor will be repaired or replaced by the Contractor without cost to the City.
2. The Contractor will be responsible for all damage to public and private property as well as all repairs outside of the limits of removal or as ordered by the Commissioner which are damaged by the Contractor must be repaired by the Contractor without cost to City.
3. The Contractor must take all necessary precautions to insure that the water pressure created by diverting or retarding the flow does not cause any damage or flooding to public or private property being served by the main sewer section being rehabilitated.
4. The Contractor's attention is called to the fact that flows in the existing sewers could flood the work under this Contract, especially in the event of heavy rains. He must be prepared at all times to safeguard workmen and protect the work under this Contract from damage by flooding. The Contractor will maintain the flow of the existing sewers.
5. The Contractor must install a screen capable of keeping debris from entering the sewer system.

3.03 INSTALLATION

A. Sewer Flow Control

1. Pumping and By-passing: When pumping and bypassing is required, the Contractor must supply the pumps, flumes, and other equipment necessary to divert the flow of waste water around the main sewer section being

rehabilitated. The contractor must submit in writing to the Commissioner for approval, a plan for pumping and bypassing. The bypass system must have the necessary capacity to handle existing flow plus additional flow that may occur during a rainstorm. The Contractor will furnish the necessary labor and supervision to set up and operate the pumping and by-pass system.

2. While performing the work under this Contract, the Contractor will comply with all applicable Federal, State and Local statutes, ordinances, and directives with respect to the elimination of excessive noise and pollution of air and water due to his operations. When pumping and by-passing is required, engines will be equipped in a manner to keep noise to a minimum.
3. Flow Control Precautions: When a main sewer is plugged, blocked, or by-passed, sufficient precautions must be taken to protect the main sewer from damage that might result from sewer surcharging. Precautions must be taken to ensure that the sewer flow control operations do not cause flooding or damage to public or private property served by the sewer being rehabilitated.

B. Pumping Discharge from Private Drains

1. This work must be performed as specified herein by a drain-layer licensed by the Department.
2. This work is required when a private drain cannot be placed out of service during the period of sewer rehabilitation work. The Contractor, in such cases, must intercept the discharge from a private drain, provide a temporary by-pass manhole, and pump the flow to a nearby active sewer.
3. The work includes pavement removal, excavation, disposing of all material, earth retention system, pumping, fluming, removing water and sewerage, furnishing all materials required to connect all existing live drains to the sewer; furnishing, placing and water jetting of trench backfill material; the bypass system for the private drains will include the temporary sump, pumping unit and discharge line to an active sewer; restoring the private drain and backfilling as specified; furnishing and placing surface restoration to the original condition or better; furnishing all materials required and all incidental work.
4. The sump pump is to be installed in a pit within the street's right-of-way, as approved by the Commissioner. After the sewer rehabilitation work is completed, the private drain by-pass including a sump, pumps, temporary discharge line, etc. must be removed. The broken drain must be replaced using short lengths of full pipe, with compression joints meeting the requirements of these Specifications. When it is not feasible to repair the drain with full lengths of pipe, a sewer repair coupling with adjustable stainless steel shear rings may be used with Commissioner's approval. Following the completion of this work the drain must be rodded and checked for proper function.
5. The sump for the private drain by-pass system must be of such size and material that no flow is permitted to infiltrate into the adjacent soil. The pump must be of adequate capacity as to handle the maximum possible flow from the drain.
6. The Contractor is to maintain an adequate and properly functioning drain by-pass system. The pumping must continue until the disconnected drain is reconnected to the sewer permitting gravity flow. The Contractor is

responsible for all property damage that is due to waste water backup from disconnected drains and damages will be recoverable from him.

7. The replacement drain pipes must be of the same material as the existing drain pipes unless otherwise approved by the Commissioner. Full length replacement drain pipes must be installed in a manner that the face of the spigot is brought into contact with the shoulder of the socket. When this is not feasible, the Commissioner may permit removal of half the circumference of the bell for ease in pipe installation. In this latter case, the pipe must be rotated by 180 degrees along the horizontal axis to bring the intact portion of the bell to the bottom of the pipe. The joints must be covered with a collar of brick and mortar, with the bricks laid perpendicular to the joint or a concrete collar formed around the connection of a structural grade concrete or grout with a minimum 28 day compressive strength of 3,000 psi.
8. The maximum width of a trench is the outside diameter of sewer plus 8 feet.
9. When water mains cross the existing drain within the limits of excavation the Contractor must support, protect and use special care in the area of the water mains. All cost incurred by reason of such work must be included in the prices bid for the appropriate items.
10. The Contractor must recognize the fact that it is impractical for utilities to relocate their lines that cross, run parallel or are within the limits of the sewer trench. Hand excavating and supporting of any and all utilities within the limits of the sewer trench will be performed by the Contractor in cooperation with the utility owners, unless advised otherwise by the Commissioner. The Contractor must provide adequate protection in conformance with the standards set forth by OSHA regulations. The Contractor must take all reasonable precautions necessary to insure the safety of its workers and the protection of the utilities encountered.
11. When the use of a trench box is approved and conditions do not permit its use due utility interference, the Contractor, must furnish, place and maintain all sheeting, bracing and shoring required to properly maintain the trench
12. Prior to starting work, the Contractor must submit the details of all by-pass systems to the Commissioner for approval.

C. Cured-In-Place Lining:

1. Proceed as soon as possible after pipeline is cleaned, necessary point repairs completed and the Commissioner has approved, in writing, the pipeline to be lined.
2. Conform to ASTM F1215.
3. The Contractor is to designate the location where the felt tube liner will be vacuum impregnated, wet-out, prior to installation.
4. Transport impregnated liner at a temperature below 40 degrees Centigrade and out of direct sunlight and install within 24-hours of wetting.
5. Insertion of prepared impregnated felt tube for:

    a. The liner for laterals must be inverted into the existing lateral sewer connection utilizing a launching, carrying and bladder devices launched in the main sewer that will effectively invert the tee-liner into the lateral sewer connection.
    b. The liner for sewers must be inserted through an existing manhole or other suitable point of access by an inversion, inside-out, process using

hydrostatic head to fully extend the felt tube to the next manhole or access point. The addition of a manhole or the modification of an existing manhole must be as defined in Section 33 39 13. Sewer Manholes, Catch Basins, Frames and Covers.

6. The cured-in-place liner must cure the inverted impregnated felt tube with a suitable heat source and water re-circulating equipment to a temperature deemed adequate by the Contractor to cure the impregnated felt tube. The water used to cure the impregnated felt tube must be cooled and the static head released in such a manner as to avoid damage to the cured liner.

    a. Gauges are to be provided to monitor ingoing and outgoing temperatures of the curing water supply and at the downstream manhole location.
    b. Temperature, in accordance with the resin manufacturer, is to be maintained until the temperature to achieve an exotherm is reached for the duration recommended and the exposed sections of liner in the up and downstream appear sound and hard.
    c. Pressure is to be maintained until the temperature of the hardened pipe is below 100 degrees Centigrade.

7. The cured resin-impregnated tube must be and be free from visual defects and:

    a. Continuous between manholes over each section of the sewer main liner.
    b. Extend over the length of the inversion as a continuous tight fitting watertight pipe-within-a-pipe for lateral liner.
    c. When cured, the tee-liner should extend between the service lateral connection and overlaps the main sewer as a continuous tight fitting watertight pipe-within-a-pipe.

D. Pumping, Bailing and Diversion

1. The Contractor must provide and maintain at all times ample means and devices for the temporary diversion of flow in existing sewers and drains and the prompt removal and proper disposal of all water or sewage entering the tunnels, trenches or other parts of the work, and must keep said excavations as dry as practicable until the structures to be built have been completed. All water pumped or drained from the work and from existing sewers must be disposed of in a suitable manner without damage to adjacent property, or to sewers, pavements, electrical conduits or other work or property. The Contractor must provide all temporary flumes or pipe lines and pumping equipment required for the proper diversion of sewage and removal of drainage from the work.
2. Whenever the Contractor, at the downstream end of his Contract, removes an existing bulkhead which was placed as part of a previous contract, he must install a screen suitable for the purpose of preventing his construction debris from floating into the completed portions of the sewer system. As his work progresses, he must also clean the completed portions of the sewer by

removing rails, jacks, lumber, sandbags and all other construction equipment, excess material and debris.

3. The Contractor must place and maintain all temporary dams, flumes, bulkheads or other structures necessary to prevent water from adjacent sections of the sewer system from entering the work under this Contract in such a manner as to injure it, and must completely remove all such temporary structures from the completed portion of the work as rapidly as practicable. The Contractor must not place a dam, flume or bulkhead in any sewer without first obtaining the approval of the Commissioner. The Contractor must ascertain the possibility of sewage backing up into basements and causing damage and he will be held responsible for any such damage.
4. The City does not assume responsibility for providing the Contractor with an outlet for any storm water or sewage which must be disposed of during the construction work under this Contract. Until the acceptance of the work, the Contractor will, if so ordered by the Commissioner, keep the entire work pumped free of water and sewage and before the acceptance of any part of the work, must clean the entire length of such finished part of the work to the satisfaction of the Commissioner.
5. Water must not be allowed to flow over or stand on the invert in such a manner as to cause scouring of the concrete surface.
6. Water pumped from trenches or other excavations must be routed to settling basins before entering the City of Chicago sewer system. The settling basins will be 5 feet by 10 feet with three (3) compartments or baffles having a minimum depth of 2 feet. Discharge from the settling basin must be by gravity to the catch basin.
7. All costs due to the provisions of this section or by interruption of the work incidental thereto, are to be included in the unit or lump sum prices stated in the proposal.

E. FINISHING OF CONTRACT WORK

1. The Contractor must protect the main sewers and sewer manholes from damage that might be inflicted by improper use of installation equipment.
2. The Contractor must ensure that a water tight seal is made at all connections in manholes and apply a seal if the installed cured tube fails to make a water tight seal. The costs for such seals are incidental to the Contract.
3. The Contractor must reconnect all active drain connections and other lateral sewers as directed by the Commissioner without excavation.
4. The Contractor must seal the liner edges between inversions / insertions or at the end of an inversion / insertion to an even thickness with a hydraulic mortar.
5. When the liner is continuous through a manhole, the liner must be trimmed flush with the wall of the bench. The cut edges must be sealed with a hydraulic mortar that adheres to both the wall of the bench and the liner.

3.04 FIELD QUALITY CONTROL

A. For the sewer liner the water tightness of the sewer liner must be gauged while curing and under a positive pressure head.

B. At each connection between the service lateral and main sewer pipe the Contractor must test the water tightness of each joint by either conducting an air pressure test or dye water flood test.

3.05 SCHEDULES

A. The Contractor must submit a schedule clearly depicting the date and duration of both the cleaning and lining work are to the Commissioner for review in accordance with Book 1, "Schedule". No work is to begin until the schedules have been submitted and reviewed by the Commissioner.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The work of CLEANING AND LINING SEWER MAINS shall not be measured for payment.

4.02 PAYMENT

A. No separate payment shall be made for the work covered in this section. Payment for the Work of CLEANING AND LINING SEWER MAINS shall be included in the contract lump sum price as shown in the Schedule of Prices for CIVIL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 020000.

END OF SECTION 33 01 10

SECTION 33 05 14

WATER VALVE BOX OR BUFFALO BOX TO BE ADJUSTED

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. The work under this Section will consist of the adjustment of existing water valve boxes or water buffalo boxes.

B. Perform in accordance with Section 565 of the Standard Specifications, the details in the drawings, and the Department of Water Managements Requirements, except as herein modified. Obtain copies of Water Service Pipe Plats from the Department of Water Management (312) 744-5078 to verify and confirm the exact location of the water service shut-off boxes.

C. Notify the Department of Water Management (312) 744-3711, 72 hours before the adjustment so that the Department can provide field inspectors to witness the work.

D. The hole formed due to adjustment of the domestic water service boxes must be backfilled with fine aggregate, gradation FA-2. Back filling is included in this item.

E. Repair damaged domestic water service boxes at Contractor's expense.

1.03 REFERENCES

A. Illinois Department of Transportation (IDOT) Standard Specifications for Road and Bridge Construction, Adopted April 1, 2016 or latest edition.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The Work of WATER VALVE BOX OR BUFFALO BOX TO BE ADJUSTED will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the Work of WATER VALVE BOX OR BUFFALO BOX TO BE ADJUSTED will be included in the contract lump sum price as shown in the Schedule of Prices for CIVIL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 020000

END OF SECTION 33 05 14

SECTION 33 05 15

CITY ELECTRICAL VAULT OR HANDHOLE TO BE ADJUSTED

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This work will consist of the adjustment of existing City of Chicago Bureau of Electricity vaults or handholes.

B. If the adjustments are to be made within the proposed Base Course Area, the work must be done in accordance with Section 602 of the Standard Specifications.

C. If the adjustments fall within an area to be resurfaced only or a parkway to be graded, the work must be done in accordance with Section 603 of the Standard Specifications.

D. Except as modified herein, the work must be performed in accordance with the applicable requirements of Special Conditions for Transportation Construction, and Additional Special Conditions, as well as the requirements of the General Conditions, Division 1, and this Section.

1.03 REFERENCES

A. Illinois Department of Transportation (IDOT) Standard Specifications for Road and Bridge Construction, Adopted April 1, 2016, or latest edition.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The Work of CITY ELECTRICAL VAULT OR HANDHOLE TO BE ADJUSTED will not be measured for payment.

4.02 PAYMENT

No separate payment will be made for the work covered in this section. Payment for the Work of CITY ELECTRICAL VAULT OR HANDHOLE TO BE ADJUSTED will be included in the contract lump sum price as shown in the Schedule of Prices for CIVIL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 020000.

END OF SECTION 33 05 15

SECTION 33 05 22

REPAIR AND ADJUSTMENT OF SEWER MAINS AND STRUCTURES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes the requirements associated with the repair, adjustment and abandonment of existing sanitary and storm sewers, private drains, manholes, catch basins and inlets as shown on the Drawings, or as directed by the Commissioner. This Section also includes the requirements for cleaning existing catch basins.

1.03 RELATED SECTIONS

A. Section 033000 – Cast-In-Place Concrete.

B. Section 312310 – Excavation, Trenching and Backfilling (Utilities).

C. Section 333113 – Sewer Main Pipe and Fittings.

1.04 REFERENCES

A. CDWM Regulations for Sewer Construction and Stormwater Management, latest edition.

B. ISPE Standard Specifications for Water & Sewer Construction in Illinois, latest edition.

C. Follow the latest edition of the following references.

1. ASTM C700 - Vitrified Clay Pipe, Extra Strength, Standard Strength and Perforated.
2. ASTM C425 - Compression Joints for Vitrified Clay Pipe and Fittings.
3. ASTM C76 - Reinforced Concrete Culvert, Storm Drain and Sewer Pipe.
4. AWWA C151 - Ductile Iron Pipe, Centrifugally Cast for Water.
5. ASTM C443 - Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets.
6. ASTM C478 - Pre-cast Reinforced Concrete. Manhole Sections.
7. ASTM C32 - Sewer and Manhole Brick (Made from Clay or Shale).

8. ASTM A48 - Gray Iron Castings.

PART 2 - PRODUCTS

2.01 PIPE AND FITTINGS

A. Sewer piping must conform to the requirements of Section 333113 – Sewer Main Pipe and Fittings.

1. Sewers 21-Inches in diameter and smaller must be Extra Strength Vitrified Clay Pipe or Ductile Iron Pipe.
2. Sewers 24-Inches and larger, must be Reinforced Concrete Pipe.

2.02 MANHOLES, CATCH BASINS AND INLETS

A. Manholes, catch basin and inlets must conform to the requirements of Section 333913 – Sewer Manholes, Catch Basins, Inlets and Special Structures.

B. Manhole lids and frames, catch basin or inlet frames, grates, and manhole steps must conform to the requirements of Section 333913 – Sewer Manholes, Catch Basins, Inlets and Special Structures.

2.03 SEWER BRICK

A. Sewer brick must conform to the requirements of Section 333913 – Sewer Manholes, Catch Basins, Inlets and Special Structures.

2.04 MORTAR AND GROUT

A. Portland Cement Mortar for sealing pipe connections, structures, manholes and catch basin frames must conform to ASTM C150, and be composed of one (1) part Portland cement and one(1) part sand, and minimal amount of water to make a workable mix.

B. Grout: Portland Cement, Admixtures, and Sand must meet the requirements of Section 033000 – Concrete.

PART 3 - EXECUTION

3.01 GENERAL

A. Existing sewer facilities disturbed or damaged by the Contractor's operation must be promptly reported to the Department of Water Management, (Sewers Engineering Section) and repaired by the Contractor. All repairs must be done using a licensed drain layer, in conformance with Department requirements, and

are considered incidental to the Work of the operation. No additional payment will be allowed for this work.

B. Sewer pipe used in the repair or adjustment of sewers and sewer structures must be of the same diameter and pipe material as the existing sewer, with the exception of the conditions listed hereafter, unless otherwise directed by the Commissioner.

1. Where water mains cross over existing sewers, house drains, catch basins drain pipes, and where an 18-inch vertical separation cannot be maintained between the bottom of the water main and top of existing sewer, the existing sewer pipe must be replaced with a ductile iron pipe with rubber gasketed joints comparable to water main standards, for a of perpendicular distance of 10 feet each side of the water main to be crossed.
2. Where the horizontal separation between a water main and existing sewer is less than 10 feet and less than 18-inches vertically above the crown of the existing sewer pipe, the sewer must be replaced with ductile iron pipe to a distance 10 foot each side of the center line of the water main.
3. If a water main crosses under existing sewers, house drains, or catch basin drains, the sewer must be replaced with ductile iron pipe to a distance of 10 feet either side of the centerline of the water main, and an 18-inch vertical separation must be maintained.

3.02 LAYING SEWERS

A. Trenches must be kept free from excess water until the sewer has been installed and mortar joints, if used, have set.

B. Each pipe and fitting must be inspected for soundness and damage immediately before being laid, and any pipe or fitting not conforming to the requirements of this Section, is rejected and must be removed from the Site at the Contractor's expense.

C. Each pipe must be laid to the line and grade as shown in the plans unless directed otherwise by the Commissioner. Pipe must be laid on even firm bedding along the entire bed of the pipe with bedding material shaped to conform to pipe bells or joint sleeves, and so not to bear on pipe bells or joints. Bedding must conform to the requirements of Section 312310 – Excavation, Trenching and Backfilling (Utilities).

D. The socket end of the pipe must be laid upgrade.

E. Pipe must not be trimmed or clipped in order to fit in the socket.

F. The face of the spigot must be brought into contact with the shoulder of the socket.

G. The joints must be sealed in accordance with the manufacturer's specifications.

H. Whenever pipe laying is discontinued, the unfinished end of the sewer must be protected from displacement, cave in, or other injury and a suitable stopper or dam must be placed in the end socket.

3.03 MORTAR JOINTS FOR DRAIN CONNECTIONS

A. Mortar joints used for connections to existing sewer pipes or private drains may be used only when connections cannot be made using gasketed joints as specified or the appropriate pipe adaptor as supplied or recommended by the pipe manufacturer, or as directed otherwise by the Commissioner.

B. When mortar joints are required, they must be constructed using the following procedure:

1. In joining pipe, the spigot must be centered in the socket by means of a packing gasket of twisted impregnated oakum of proper thickness and sufficient length to pass around the pipe and lap the top.
2. After the pipe has been placed, the gasket must be caulked into the annular space and the remainder of the space filled with Portland cement mortar beveled off with the outside of the socket.
3. Mortar for pipe joints or fittings must be made of one (1) part Portland Cement and one (1) part sand conforming to applicable requirements of Section 033000 -Concrete.
4. Only a sufficient amount of mortar may be prepared for use within forty-five (45) minutes of application. Any mortar that has begun to set must not be used.
5. As each joint is completed, the inside of the pipe must be thoroughly cleaned to remove all excess joint material.

3.04 EXISTING CATCH BASINS

A. Thoroughly clean any existing catch basin to remain to its full depth, removing and properly disposing of all material removed from the basin. No material removed from a catch basin must be allowed to enter any City sewer.

B. Inspect the drain connection from each catch basin and rod-out the drain when said drain is found to have obstructions. Any drain connection found to be defective must be removed and relayed.

3.05 REPAIR AND ADJUSTMENT OF STRUCTURES

A. Remove the existing frames and covers and inspect the existing masonry. Remove and replace defective masonry in the upper portions. Remove or add masonry, as necessary, to meet the elevations as shown on the Plans.

B. For any manhole or catch basin cover or frame raised more than 6 inches, remove the old masonry for the structure to the point where the manhole or catch basin structure reaches its full internal diameter and rebuild the structure as shown on the Plans.

C. Material used in each repair and adjustment must be the same type as in the existing manhole, catch basin or inlet, unless otherwise ordered by the Commissioner.

D. Reset the existing frames and covers on the repaired and adjusted manholes, catch basins and inlets in a full bed of mortar. If new covers are required, they will be furnished and installed at no additional cost to the Commissioner.

E. Examine the drain connection from each catch basin and inlet, and if such connection is found to be defective, then remove and relay the defective portions as ordered by the Commissioner.

F. Place granular trench backfill, as described in Section 312310 – Excavation, Trenching and Backfilling (Utilities), around the repaired and adjusted manholes, catch basins, inlets, valve basins and vaults.

3.06 FINAL ADJUSTMENT OF STRUCTURES

A. To prevent debris from entering the sewers, place 22 gauge galvanized steel plate beneath all perforated lids of all sewer structures prior to the placing of any type of surfacing material. Maintain plates in place until the completion of all paving operation have been completed.

B. After the base course and binder course have been placed, and prior to placing the surface course, the structures must be adjusted to match the final pavement elevation.

C. Remove the binder and base course adjacent to and for a distance not exceeding 12-inches outside the base of the castings.

D. Adjust the castings to final pavement elevation with adjusting rings set in mortar.

E. Fill the space around the casting with Class SI concrete to the elevation of the surface of the binder course.

3.07 ABANDONMENT OF SEWERS AND SEWER STRUCTURES

A. Fill abandoned sewers, sub-sidewalk space, water tunnels, structures, drains, manholes, catch basins and inlets as shown on the Plans or as ordered by the Commissioner with fine aggregate material meeting the requirements of Section 312310 – Excavation, Trenching and Backfilling (Utilities). A hole must be drilled every 100 feet in abandoned backfilled sewers and drains that are 15 inches and larger in internal diameters to verify the backfilling and to allow refilling if necessary.

B. When called for on the Drawings, abandoned sewers must be completely filled with sewer grout or controlled low strength material / flowable fill. Fill abandoned sewers to a point approximately six (6) inches up in the manhole riser above the top of the sewer crown. Care must be taken so as not to fill any drain connection.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The work of REPAIR AND ADJUSTMENT OF SEWER MAINS AND STRUCTURE shall not be measured for payment.

4.02 PAYMENT

A. No separate payment shall be made for the work covered in this section. Payment for the Work of REPAIR AND ADJUSTMENT OF SEWER MAINS AND STRUCTURE shall be included in the contract lump sum price as shown in the Schedule of Prices for CIVIL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 020000.

END OF SECTION 33 05 22

SECTION 33 12 13

WATER SERVICES

PART 1 –GENERAL

1.01 DESCRIPTION OF WORK

A. This section includes the requirements for the installation of water services 2-Inch and smaller in diameter as shown on the Drawings and specified here.

1.02 REFERENCES

A. City of Chicago Plumbing Code, latest edition.
B. ASTM B62 -Composition of Bronze or Ounce Metal Castings, latest edition.
C. ASTM B63 -Resistivity of Metallically Conducting Resistance and Contact Materials, latest edition.
D. ASTM B88 -Seamless Copper Water Tube, latest edition.
E. ASTM B584 –Copper Alloy Sand Castings for General Applications, latest edition.
F. AWWA C800 -Underground Service Line Valves and Fittings, latest edition.
G. NSF / ANSI Standard 61 –Drinking Water System Components Health Effects

1.03 SUBMITTALS

A. Refer to Book I for submittal requirements and procedures for Shop Drawings, Product Data, Records and Samples.

B. The Contractor must provide the Commissioner, prior to the use of any materials in this section, certified test and inspection reports from an approved testing laboratory, or at the point of manufacture, that all materials and/or equipment to be utilized in this work are in accordance with the Contract Documents.

C. All tests as specified are to be performed at the point of manufacture. The cost of testing is considered incidental to the construction and no additional payment will be allowed.

D. Each individual unit must be pressure tested and guaranteed for service at pressures minimally equal to pressure ratings specified for design purposes in AWWA C800. Additionally, all materials must comply with NSF 61. The

Contractor must provide an affidavit that materials furnished comply with the above standards.

1.04 QUALITY ASSURANCE

A. The Work necessary for the installation of new, or modification to existing services, must be performed by a plumber licensed in the State of Illinois or the City. This Work will include, but is not limited to, tapping the main; installing corporation cocks; cutting and flaring the ends of copper tubing; installing copper tubing, fittings, and round way (curb stop) valves; and connecting new service tubing to existing services, as specified herein.

PART 2 –PRODUCTS

2.01 COPPER TUBING

A. Type "K" (soft) copper tubing, seamless annealed conforming to ASTM B88.

2.02 ROUNDWAY (CURB STOP)

A. All round ways must be ball valve type with copper flare connections on both ends and Minneapolis type curb box threads. The round way must conform to requirements of AWWA C800. Minneapolis thread size for 1- Inch round way will be 1½-Inches; 1 ½-Inch and 2-Inch round ways will be 2-Inches.

B. Round ways must be composed of bronze or ounce metal alloy conforming to the chemical and physical requirements of ASTM B62 and AWWA C800. Castings must be high grade, smooth, and free from sand, blowholes, shrinkage, or other foundry defects. No round way can be plugged or filled in any manner. All threads must be cut full and without defects.

C. Any brass part of the fitting or valve in contact with potable water shall be made of a “No-Lead Brass”, defined as UNS Copper Alloy No. C89520 or C89833 in accordance with the chemical and mechanical requirements of ASTM B584 and AWWA C800. This “No-Lead Brass” alloy shall not contain more than one quarter of one percent (0.25% or less) total lead content by weight.

D. Acceptable manufactures and products for round way valves are A.Y. McDonald, model #6104, Ford Meter Box, model #B22-M, or Mueller, model #B-25154.

2.03 SHUT-OFF BOX

A. Shut-off boxes must conform to details for the “Plastic Shut-off Box - Type B”

shown in the Drawings, as manufactured by C.P. Test Services- Valvco, Inc.

B. The shut-off box is to be manufactured from ABS plastic, and be of a two (2) piece tubular design, employing sliding friction between the upper and lower tube sections to maintain length adjustments. A threaded bushing is to be bonded to the plastic of the bottom end section to enable attachment to around way (curb stop) shut-off valve. A cast iron lid and rim is to be bonded to the plastic of the top section of the unit. The lid is to have a removable pentagon head bolt for locking the lid into the rim. The letters "WATER" must be cast on the top of the lid. The total length of the plastic shut-off box must be a minimum of 72-Inch when fully extended.

2.04 BRASS CORPORATION COCKS

A. Corporation cocks for water service connections must be of a plug type design conforming to ASTM B62 and AWWA C800. Corporation cocks shallbe furnished with a 1/8-bend tailpiece coupling, inlet endswivel nut with female flare copper thread and gasket, and outlet end copper flare connection, as manufactured by A.Y. McDonald,model #4701L,with model # 4750S couplings, or equivalent.Reference CONSTRUCTON DETAIL D-16, in Appendix A.

B. 1-Inch corporation cocks used for test taps (Valves 8-Inch to 12-Inch)must be ordered without gasket, coupling nut and tailpiece, and be of type manufactured byA. Y. McDonald, model #3120C, or equivalent.Reference CONSTRUCTON DETAIL D-13, in Appendix A.

2-Inch corporation cocks used for test taps (Valves 16-Inchand larger)must be ordered without gasket, coupling nut, and tailpiece, and be of type manufactured by A.Y. McDonald,model #3131, or equivalent.Reference CONSTRUCTON DETAIL D-13, in Appendix A.

C. Corporation cocks must be manufactured fromcomposition bronze or ounce metal alloy conforming to ASTM B62 and AWWA C800. The valve castings must be high grade, smooth, and free from sand, blowholes, shrinkage, or other foundry defects. Castings must not beplugged or filled in any manner. All threads must be cut full and without defects. All gaskets, screws, or other parts necessary for proper installation and operation of the corporation stop must be supplied.

D. Any brass part of the fitting or valve incontact with potable water shall be made of a "No-Lead Brass", defined as UNS Copper Alloy No. C89520 or C89833 in accordance with the chemical and mechanical requirements of ASTM B584 and AWWA C800. This "No-Lead Brass" alloy shall not contain more thanone

quarter of one percent (0.25% or less) total lead content by weight.

2.05 COMPRESSION COUPLINGS

A. Provide compression couplings to join lead or iron water services to brass fittings and copper water services. Couplings must be manufactured from composition bronze or ounce metal alloy conforming to ASTM B62 and AWWA C800.Castings must be high grade, smooth, and free from sand, blowholes, shrinkage, or other foundry defects. No coupling may be plugged or filled in any manner. All threads must be cutfull and without defects.

B. Any brass part of the fitting or valve in contact with potable water shall be made of a "No-Lead Brass", defined as UNS Copper Alloy No. C89520 or C89833 in accordance with the chemical and mechanical requirements of ASTM B584and AWWA C800. This "No-Lead Brass" alloy shall not contain more than one quarter of one percent (0.25% or less) total lead content by weight.

C. Couplings mustbe equipped with clamps or setscrews to engage the pipe and act as locking devices. Screws must be manufactured fromsilicone bronze or stainless steel.

D. Furnish the appropriate type and number of compression couplings listed below for connectingexisting water services to the brass fittings or copper water services:

1. 1-Inch strong lead to 1-Inch copper flare.

2. 1 ½-Inch extra strong lead to 1 ½-Inch copper pack fitting.

3. 2-Inch extra strong lead to 2-Inch copper pack fitting.

4. 1-Inch strong lead to 1-Inch MIP thread.

5. 1 ½-Inch extra strong lead to 1 ½-Inch MIP thread.

6. 2-Inch extra strong lead to 2-Inch MIP thread.

7. 1-Inch strong lead to 1-Inch strong lead.

8. 1-Inch extra strong lead to 1-Inch copper flare.

9. 1-Inch extra strong lead to 1-Inch MIP thread.

10. 3/4-Inch strong lead to 3/4-Inch FIP thread.

11. 3/4-Inch strong lead to 3/4-Inch strong lead.

12. 3/4-Inch iron pipe to 3/4-Inch FIP thread.

13. 5/8-Inch strong lead to 3/4-Inch FIP thread.

14. ½-Inch strong lead to 3/4-Inch MIP thread.

E. Acceptable manufactures forcompression coupling kits are Ford Meter Box,"Lead-Pak"and "Pack Joint" kits;A.Y. McDonald,"Mac-Pak"or "Compression Coupling"kits;or Mueller "Pack Joint" kit.

2.06 BRASS AND COPPER PIPE FITTINGS AND COUPLINGS

A. Fittings and couplings must be manufactured from composition bronze or ounce metal alloy conforming ASTM B62 and AWWA C800. Castings must be high grade, smooth, and free from sand, blowholes, shrinkage, or other foundry defects. No coupling or fitting may be plugged or filled in any manner. All threads must be cut full and without defects.

B. Any brass part of the fitting or valve in contact with potable water shall be made of a "No-Lead Brass", defined as UNS Copper Alloy No. C89520 or C89833 in accordance with the chemical and mechanical requirements of ASTM B584 and AWWA C800. This "No-Lead Brass" alloy shall not contain more than one quarter of one percent (0.25% or less) total lead content by weight.

C. Furnish the appropriate number of brass and copper fittings and couplings listed below needed to connect the existing water services to the new main.

1. 3/4-InchFIP X 1-Inchflare.

2. 1-InchFIP X 1-Inchflare.

3. 1 ½-InchFIP X 1 ½-Inchflare.

4. 2-InchFIP X 2-Inchflare.

5. 3/4-InchMIP X 1-Inchflare.

6. 1-InchMIP X 1-Inchflare.

7. 1 ½-InchMIP X 1 ½-Inchflare.

8. 2-InchMIP X 2-Inchflare.

9. 3/4-InchFIP X 1-InchMIP.

10. Unions, 1-Inch, 1 ½-Inch, 2-Inch, three parts, flared both ends.

11. Tube nuts, 1-Inch, 1 ½-Inch, 2-Inch.

D. Furnish fittings and couplings by A.Y. McDonald, Ford Meter Box, or Mueller.

2.7 2-INCH COMBINATION AIR RELIEF VALVE ASSEMBLY

A. Where shown or specified, the Contractor must furnish 2-Inchcombination air relief assemblies. The 2-Inchcombination air relief assemblies must be Val- Matic Model 202 C or APCO Model 145C.

PART 3 – EXECUTION

3.1 ADJUSTMENT OF SHUT-OFF BOXES AND VALVE BOXES

A. The Contractor is responsible for vertically adjusting existing water service shut-off boxes and valve boxes to the proper surface elevation as shown on Plans, or directed by Commissioner. The Contractor must obtain copies of information forwater service pipe from the Department to verify and confirm the exact location of water shut-off boxes or valve boxes to be adjusted. The Contractor must notify the Department seventy-two (72) hours before the excavation of sidewalk or parkway commences to determine if the services are active and also to clarify any discrepancies with water service pipe plats and field survey.

B. If a service is inactive, the Contractor must cut the top part of the box 36-Inches below the proposed grade and backfill.

C. If the service is active and the shut-off/valve box is made of plastic or other approved materials, the Contractor must excavate and vertically adjust the box to proposed grade.If the existing shut-off/valve box is made of cast iron, the top 36-Inches of the box must be replaced with a length of plastic tubing sleeved over the existing shut-off/valve box. The cast iron rim must be bonded to the top of the plastic tubing. The materials and dimensions of the plastic tubing and cast iron rim must conform to the requirements as specified herein and shown in the Drawingsfor Plastic Shut-off Box-Type B.

3.2 DIRECT TAPPING OF DUCTILE IRON PIPE ENCASED IN POLYETHYLENE FILM

A. Installation procedures must be a method as recommended bythe Ductile Iron Pipe Research Association:

1. Method 1: Apply two (2) or three (3) wraps of polyethylene adhesive tape completely around the pipe to cover the area where the tapping machine and chain will be mounted. After the tapping machine is mounted, install the corporation stop directly through the tape and polyethylene. After the direct tap is completed, inspect the entire circumferential area for damage and repair as needed.

2. Method 2: Directly tap through the polyethylene film without applying a layer of tape on the encasement. Mount the tapping machine directly on the polyethylene encased pipe and install the corporation stop using normal tapping procedures. Once the direct service connection is completed, repair all polyethylene that may have been damaged during the procedure. Inspect the bottom of the encased pipe where the mounting chain has been in contact with the polyethylene for damage and repair as needed.

3. Method 3: Make an X-shaped cut in the polyethylene and temporarily fold back the film at the point where the corporation stop will be installed. Then mount the tapping machine over the exposed pipe surface and make the service tap. After the tap is made and the corporation installed, remove the tapping machine and repair the "X" shaped cut with polyethylene-compatible adhesive tape.

B. Before backfilling. Inspect the polyethylene around the exposed circumferential area, particularly at the bottom where the mounting chain has been in contact with the polyethylene, to ensure that all damage is repaired.

C. House Services.Wrap the attendant corporation stop and a minimum clear distance of 3-feet of the copper service with polyethylene or a suitable dielectric tape.

3.3 WATER SERVICE GENERAL NOTES

A. It is the contractor's responsibility to determine the size and location of each service connection prior to installation of the proposed water main.

B. The Contractor must test all services for flow. If the service has water flow, it must be connected to the new water main.

C. It is the Contractor's responsibility to transfer all active services to the new water main.

D. If a water service is not in use, abandon the service with the existing main. When it is necessary to break a service that is to be abandoned with the existing water main, the service pipe must be crimped on each end to seal the abandoned pipe. Any shut off box for an abandoned service that is visible at the surface must be broken off two (2) feet below grade in the parkway or sidewalk, backfilled with CA-16 trench backfill material and restored to parkway or sidewalk, as appropriate.

E. Remove frames and lids and meters from abandoned meter vaults and fill with CA-16 trench backfill material and restore the surface. Return meters to DWM.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The Work of WATER SERVICES will not be measured for payment.

4.02 PAYMENT

A. Payment for the Work of coordinating WATER SERVICES will be included the contract lump sum price for Civil Work.

4.03 PAY ITEM ACCOUNT NUMBER

Civil Work: 020000

END OF SECTION 33 12 13

SECTION 33 12 14

WATER SERVICE TERMINATION

PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

A. This section includes the requirements for the termination of water services
2-Inch and smaller in diameter as shown on the Drawings and specified here.

1.2 REFERENCES

A. City of Chicago Plumbing Code, latest edition.
B. ASTM B62 - Composition of Bronze or Ounce Metal Castings, latest edition.
C. ASTM B63 - Resistivity of Metallically Conducting Resistance and Contact Materials, latest edition.
D. ASTM B88 - Seamless Copper Water Tube, latest edition.
E. ASTM B584 – Copper Alloy Sand Castings for General Applications, latest edition.
F. AWWA C800 - Underground Service Line Valves and Fittings, latest edition.
G. NSF / ANSI Standard 61 – Drinking Water System Components – Health Effects

1.3 SUBMITTALS

A. Contact the Department of Buildings. Buildings-Plan Section or the Chief Plumbing Inspector to coordinate this work.

1.4 QUALITY ASSURANCE

A. The Work necessary for the cut and seal of existing water services must be performed by a plumber licensed in the State of Illinois or the City. This Work will include, but is not limited to, cutting and sealing existing tap at the main; removal of existing corporation cocks; removing existing copper tubing, fittings, and roundway (curb stop) valves; as specified herein.

PART 2 – PRODUCTS

2.1 COPPER TUBING SEALING

A. Material as approved by Department of Water Management and Chief Plumbing Inspector.

PART 3 – EXECUTION

3.1. ADJUSTMENT OF SHUT-OFF BOXES AND VALVE BOXES

A. The Contractor is responsible for termination services by a licensed plumber per DWM standards which includes but is not limited to obtaining all applicable permits, tracing equipment, excavations/OSHA shoring, backfilling/compaction, abandonment of appurtances (meter vault/valve box/valve basin) and restoration to CDOT standards. The Contractor must contact the Chief Plumbing Inspector at 312-744-7017 to coordinate the work. DWM Inspection Fee for Regular Time (7am-3pm)= $420 per service stub. Premium Time outside (7 am – 3 pm) = $510.

The Contractor must notify the Department seventy-two (72) hours before the excavation of sidewalk or parkway commences to determine if the services are active and also to clarify any discrepancies with water service pipe plats and field survey.

3.3 WATER SERVICE GENERAL NOTES

A. If a water service is not in use, abandon the service with the existing main. When it is necessary to break a service that is to be abandoned with the existing water main, the service pipe must be crimped on each end to seal the abandoned pipe. Any shut off box for an abandoned service that is visible at the surface must be broken off two (2) feet below grade in the parkway or sidewalk, backfilled with CA-16 trench backfill material and restored to parkway or sidewalk, as appropriate.

B. Remove frames and lids and meters from abandoned meter vaults and fill with CA-16 trench backfill material and restore the surface. Return meters to DWM.

PART 4 – MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. WATER SERVICE TERMINATION will be not be measured for payment.

4.02 PAYMENT

A. Payment for the Work of to complete WATER SERVICES TERMINATION will be included in the lump sum price for Civil Work.

4.03 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 020000

END OF SECTION 33 12 14

SECTION 33 31 13

SEWER MAIN PIPE AND FITTINGS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This section includes requirements for the installation of sewer mains, service piping and accessories, adjustment of sewer pipes, house drains, manholes, catch basins, inlets and associated appurtenances specified here, shown on the Drawings, or directed by the Commissioner.

1.03 RELATED SECTIONS

A. Section 312319 - Dewatering Excavations.

B. Section 312310 - Excavation, Trenching and Backfilling (Utilities).

C. Section 033000 - Concrete.

D. Section 333913 - Sewer Manholes, Catch Basins, Inlets and Special Structures.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM), latest edition:

1. ASTM A74 - Specification for Cast Iron Soil Pipe and Fittings
2. ASTM C12 - Practice for Installing Vitrified Clay Pipe Lines
3. ASTM C14 - Specification for Concrete Sewer, Storm Drain and Culvert Pipe.
4. ASTM C76 - Specification for Reinforced Concrete Culvert, Storm Drain and Sewer Pipe.
5. ASTM A48 - Gray Iron Castings.
6. ASTM C32 - Sewer and Manhole Brick (Made from Clay or Shale).
7. ASTM C361 - Standard Specification for Reinforced Concrete Low-Head Pressure Pipe
8. ASTM C425 - Specification for Compression Joints for Vitrified Clay Pipe and Fittings.

9. ASTM C443 / AASHTO M198 - Specification for Joints for Circular Concrete Sewer and Culvert Pipe, using Rubber Gaskets.
10. ASTM C506 - Specification for Reinforced Concrete Arch Culvert, Storm Drain and Sewer Pipe.
11. ASTM C507 - Specification for Reinforced Concrete Elliptical Culvert, Storm Drain and Sewer Pipe.
12. ASTM C564 - Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
13. ASTM C700 - Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength and Perforated.
14. ASTM C 1173 - Standard Specifications for Flexible Transition Couplings for Underground Piping.
15. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.

B. AWWA C151 - Ductile Iron Pipe, Centrifugally Cast for Water, latest edition.

C. ANSI A21.11 - Rubber Gasket Joints for Cast Iron and Ductile Iron Pressure Pipe and Fittings, latest edition.

D. AWWA C104 - Cement Mortar Lining for Ductile Iron Pipe and Fittings, latest edition.

E. AWWA C110 - Ductile-Iron and Gray-Iron Fittings, latest edition.

F. AWWA C150 - Thickness Design of Ductile-Iron Pipe, latest edition.

G. AWWA C151 - Ductile Iron Pipe, Centrifugally Cast, latest edition.

H. ISPE Standard Specifications for Water & Sewer Construction in Illinois, latest edition.

I. CDWM Regulations for Sewer Construction and Stormwater Management, latest edition.

1.05 SUBMITTALS

A. Reference City of Chicago, Department of Procurement, Book I -“Terms and Conditions for Construction” for submittal requirements and procedures for Shop Drawings, Product Data, Records and Samples.

B. The Contractor must give notice, in writing to the Commissioner, sufficiently in advance of the intention to commence the purchase and/or manufacture of the pipe for use under this contract.

C. Before starting fabrication of the pipe and fittings, the Contractor must submit fully dimensioned drawings or catalogs to the Commissioner showing the pipe, joints and fittings to be used in the Work in full detail.

D. Submit a copy of sewage bypass plan to the Commissioner.

E. The Contractor must submit to the Commissioner certified copies of all test reports.

F. The Contractor must provide the Commissioner with a notarized statement that all tests have been made and met as specified here, unless waived by the Commissioner.

1.06 QUALITY ASSURANCE

A. The contractor must furnish all facilities, personnel, and materials to conduct tests required as applicable to the type of pipe being supplied. The cost of all plant tests required as proof of the acceptability of the material will be considered incidental to the Work and no additional payment will be allowed.

B. The Work performed on joining all pipe and fittings, must be performed by a licensed drain layer in the City of Chicago. This Work must include, but not be limited to joining all pipe and fittings, coring sewer pipe sections, installing joint gaskets, assembling all joints, installing continuity wedges, and tightening all gland nuts and bolts, as applicable for the installation.

C. All pipe and fittings must be inspected for soundness and damage due to handling, immediately before being laid and any not conforming to these requirements of this Section is rejected and must be immediately removed from the site.

PART 2 - PRODUCTS

2.01 PIPE AND FITTINGS

A. VITRIFIED CLAY PIPE

1. Vitrified clay pipe to be used for all pipes 21” in diameter and smaller.
2. Vitrified clay pipe and fittings must be extra strength clay bell and spigot pipe conforming to the requirements of ASTM C700.

a. Reinforced Concrete Pipe

1) Reinforced concrete pipe to be used for all pipes greater than 21” in diameter.
2) Circular reinforced concrete pipe and fittings must conform to the requirements of ASTM C76, Class III, IV or V, Wall B or Wall C with circular reinforcement. For pipe thirty (30) inches or more in diameter, the length of the unit must not be less than six (6) feet. Elliptical section reinforced concrete pipe and fittings must conform to ASTM C507, minimum class HE-III or HE-IV. Arch section reinforced concrete pipe and fittings must conform to ASTM C506, minimum class A-III or A-IV.
3) Preformed tapered holes of the proper dimensions as shown on the Plans for the connection of drains and future drain connections must be provided during the manufacture of the pipe. Tapered holes must be so formed that the drain connection will enter the sewer at an angle of approximately 90 degrees with the axis of the sewer. Whenever the

diameter of a preformed tapered hole is equal to or exceeds 50 percent of the diameter of the pipe, additional reinforcement steel satisfactory to the Commissioner must be placed around the hole.

4) Selection of Pipe Class for Reinforced Concrete Pipe must comply with Tables 1, 2 or 3 of this Section.

Table 1
Required Pipe Class by Diameter and Type for Circular Pipe

Pipe Size (inches)	Type 1 1	Type 2 2	Type 3 3	Type 4 4	Type 5 5	Type 6 6	Type 7
24	IV	III	IV	V	V	V	V
27	IV	III	IV	V	V	V	V
30	III	III	IV	V	V	V	V
36	III	III	IV	IV	V	V	V
42	III	III	IV	IV	V	V	V
48	III	III	IV	IV	V	V	V
54	III	III	IV	IV	V	V	V
60	III	III	IV	IV	V	V	V
66	III	III	III	IV	IV	V	V
72	III	III	III	IV	IV	V	V
78	III	III	III	IV	IV	V	V
84	III	III	III	IV	IV	V	V
90	III	III	III	IV	IV	V	V
96	III	III	III	IV	IV	V	V
102	III	III	III	IV	IV	V	V
108	III	III	III	IV	IV	V	V

TABLE 2
Required Pipe Class by Size and Type for Elliptical Pipe

Equiv. Round Dia. (inches)	Span (inches)	Rise (inches)	Type 1 1	Type 2 2	Type 3 3
24	30	19	HE-IV	HE-III	HE-III
27	34	22	HE-III	HE-III	HE-III
30	38	24	HE-III	HE-III	HE-III
36	45	29	HE-III	HE-III	HE-III
42	53	34	HE-III	HE-III	HE-III
48	60	38	HE-III	HE-III	HE-III
54	68	43	HE-III	HE-III	HE-III
60	76	48	HE-III	HE-III	HE-III
66	83	53	HE-III	HE-III	HE-III
72	91	58	HE-III	HE-III	HE-III

TABLE 3
Required Pipe Class by Size and Type for Elliptical Pipe

Equiv. Round Pipe Size (inches)	Span (inches)	Rise (inches)	Type 1 1	Type 2 2	Type 3 3
24	28 ½	18	A-IV	A-III	A-III
27	36 ¼	22 ½	A-III	A-III	A-III
30	36 ¼	22 ½	A-III	A-III	A-III
36	43 ¾	26 5/8	A-III	A-III	A-III
42	51 1/8	31 5/16	A-III	A-III	A-III
48	58 ½	36	A-III	A-III	A-III
54	65	40	A-III	A-III	A-III
60	73	45	A-III	A-III	A-III
66	88	54	A-III	A-III	A-III
72	88	54	A-III	A-III	A-III

Notes For Tables 1, 2 & 3:

1. Type 1 – Depth: 3-feet and <
2. Type 2 – Depth: >3-feet and <10-feet.
3. Type 3 – Depth: 10-feet and <15-feet.
4. Type 4 – Depth: 15-feet and <20-feet.
5. Type 5 – Depth: 20-feet and <25 feet.
6. Type 6 – Depth: 25-feet and <30 feet.
7. Type 7 – Depth: 30–feet and >.

B. DUCTILE IRON Pipe (If not Required to be deleted for next submittal)

1. Ductile iron pipe must conform to the requirements of AWWA C151, Class 52 and with the additions or substitutions specified in this Section. Fittings 12" and larger must be gray or ductile iron conforming to ASTM C110. Fittings 10" and smaller must be gray or ductile iron conforming to ASTM C153.
2. Bells must be designed to provide a watertight joint without any leakage and be capable of withstanding pressures exceeding those that will rupture pipe of this class and thickness without requiring additional jointing material.
3. All pipe must be manufactured so that where a cut is made at any point along the barrel, the cut end will fit properly into a standard mechanical joint bell and be drip tight at hydrostatic test pressure.
4. Exterior of pipe and fittings must be coated with a petroleum asphaltic material in conformance with AWWA C110, Section 10-10. Interior of pipe must be cement mortar or ceramic lined in accordance with AWWA C104.

C. Masonry

1. Sewer brick and mortar must conform to the requirements of Section 333913 – Sewer Manholes, Catch Basins, Inlets and Special Structures.

2.02 PIPE JOINTS

A. Vitrified Clay Pipe

1. Vitrified clay pipe joints must be resilient, compression-type joints conforming to ASTM C425. Joints may be provided in one of the following ways:

a. Joints made of polyurethane must have an integral compression ring formed as part of the factory made joint.
b. Where rubber gaskets are used, they must be continuous precision molded gaskets manufactured from a compound containing a basic polymer of not less than 50% by volume of isoprene and must contain no vulcanized vegetable oil, reclaimed rubber or dry deleterious substance.

B. Reinforced Concrete Pipe

1. Reinforced concrete pipe joints must be flexible rubber gasket joint type conforming to ASTM C361, ASTM C443 and AASHTO M198.

C. Ductile Iron Pipe (If not Required to be deleted for next submittal)

1. Pipe joints must be push-on type joints with rubber gaskets unless otherwise shown on the Drawings, specified, or directed by the Commissioner. Push-on type joints must conform to AWWA C111.

D. PVC JOINTED PIPE

1. For vitrified clay pipe size 12-inch in diameter or smaller, Contractor may substitute a polyvinyl chloride (PVC) sleeve with a polyurethane jointing material for the joint in 2.2.A. PVC collar conforming to ASTM D1784, Class 12454-B must be installed on the extra strength clay pipe at the factory. The finished joint must meet or surpass all applicable material and performance tests specified for clay pipe joints under ASTM C425.

E. JOINING PIPE OF DISSIMILAR MATERIALS

1. For pipes 15-inches and smaller in diameter, connect pipe of dissimilar material together with manufactured flexible transition couplings specifically made for this purpose, conforming to ASTM C 1173. Transition couplings are to be molded from synthetic elastomeric materials fitted with attached adjustable stainless steel band type clamps to stabilize and seal the joint. Acceptable products are “Band Seal Couplings made by Naylor Inc., “Mission Couplings” made by Mission Rubber Co.,or “Fernco Couplings” made by Fernco Systems, Inc.
2. For sewer pipes larger then 15-inches in diameter, transitions between different pipe materials must be as directed by the Bureau of Sewers.

2.03 POLYETHYLENE ENCASEMENT FOR CAST OR DUCTILE IRON PIPE (IF NOT REQUIRED TO BE DELETED FOR NEXT SUBMITTAL)

A. For cast iron and ductile iron pipe, polyethylene encasement material must be 4-mil, cross-laminated, high-density polyethylene tubing. The tubing must comply with AWWA C105.

2.04 SEWER CLEANOUTS (IF NOT REQUIRED TO BE DELETED FOR NEXT SUBMITTAL)

A. At grade cleanouts must be cast iron pipe and have an adjustable sleeve-type housing, a threaded brass plug with countersunk clot and cast iron frame and cover.

2.05 CAST-IN-PLACE CONCRETE

A. Cast in Place Concrete must conform to the requirement of Section 033000 – Concrete.

2.06 PIPE BEDDING

A. Pipe bedding must conform to requirements set forth in Section 312310 – Excavation, Trenching, and Backfilling (Utilities), of these specifications.

PART 3 - EXECUTION

3.01 GENERAL

A. All pipe, fittings, and appurtenances must be installed in accordance with the manufacturer's recommendations and requirements.

B. All pipe, fittings, and accessories must be delivered, unloaded, strung, and laid as specified here.

3.02 TRANSPORTATION AND DELIVERY OF PIPE, FITTINGS AND STRUCTURES

A. Every precaution must be taken to prevent damage to the pipe during transportation and delivery. Extreme care must be taken in loading and unloading the pipe and fittings. Such work must be done with the pipe under complete control at all times. Under no conditions may the pipe be dropped, bumped, dragged, pushed, or moved in any way that will cause damage to the pipe.

B. If in the process of transportation, handling, or installation, any pipe or fitting is damaged, such pipe or fitting must be replaced by the Contractor and be considered incidental to the construction and no additional payment will be allowed.

C. The Contractor must prevent the pipe from rolling. The procedures used to prevent rolling must be approved by the Commissioner.

3.03 SEWAGE DIVERSION

A. By-pass pumping will be required for sections of sewer main being replaced as indicated on the Drawings. All pumping shall be included as incidental to construction of the new sewer main.

B. The Contractor must include in his construction procedure adequate means for pumping and diverting all sewage flow around the work area to keep the trench free of water and sewage until all structures, pipe, and connections have been completed. During heavy rains, the Contractor must anticipate additional flow from surface runoff and in existing sewers. The Contractor must be prepared to handle the increased flow under these conditions and protect the new work from damage while keeping all excavations as dry as possible and existing sewers in operation. Any additional pumping needed during times of heavy rainfall will be considered incidental to the cost of the by-pass pumping and will not be considered for additional payment.

C. No open pumping or discharge of water will be allowed onto City streets. All discharge flows must be discharged via pumping through a closed system of pipelines to an approved discharge point. It is part of the work of this section for the Contractor to submit a bypass pumping plan for the review and comment of the Department of Water Management, Sewer Section, before starting any work. The Contractor must provide all temporary flumes or pipe lines and pumping equipment required for the proper diversion of sewage and removal of drainage from the work. Contractor must remove any temporarily-installed dams or bulkheads after completion of the work.

D. Whenever the Contractor, at the downstream end of his Contract, removes an existing bulkhead which was placed as part of a previous contract, he must install a screen suitable for the purpose of preventing his construction debris from floating into the completed portions of the sewer system. As his work progresses, he must also clean the completed portions of the sewer by removing rails, jacks, lumber, sandbags and all other construction equipment, excess material and debris.

E. The Contractor must place and maintain all temporary dams, flumes, bulkheads or other structures necessary to prevent water from adjacent sections of the sewer system from entering the work under this Contract in such a manner as to injure it, and must completely remove all such temporary structures from the completed portion of the work as rapidly as practicable. The Contractor must not place a dam, flume or bulkhead in any sewer without first obtaining the approval of the Commissioner. The Contractor must ascertain the possibility of sewage backing up into basements and causing damage and he will be held responsible for any such damage.

F. The City does not assume responsibility for providing the Contractor with an outlet for any storm water or sewage which must be disposed of during the construction work under this Contract. Until the acceptance of the work, the Contractor will, if so ordered by the Commissioner, keep the entire work pumped free of water and sewage and before the acceptance of any part of the work, must clean the entire length of such finished part of the work to the satisfaction of the Commissioner.

G. Water must not be allowed to flow over or stand on the invert in such a manner as to cause scouring of the concrete surface.

H. Water pumped from trenches or other excavations must be routed to settling basins before entering the City of Chicago sewer system. The settling basins must be 5 feet by 10 feet with three compartments or baffles having a minimum depth of 2 feet. Discharge from the settling basin must be by gravity to the catch basin.

3.04 STORAGE OF CONCRETE PIPE AND STRUCTURES

A. In order to minimize inconvenience to adjacent property owners, the Contractor must not store pipe or structures on the job site for a distance of more than 600 feet ahead of the trench excavation. Stacking of concrete pipe is not allowed.

3.05 PREPARATION FOR LAYING PIPE

A. Materials, coatings, and linings must be as specified and as shown. Installation must be in accordance with standards as recommended by the pipe manufacturer, and as specified here.

B. Proper and suitable tools and appliances for the safe and convenient cutting, handling, and laying of the pipe and fittings must be used.

C. Before lying, all pipe and fittings must be thoroughly examined for defects and no piece may be installed which is known to be defective. If defects are discovered after pipe or fittings have been installed, the Contractor must remove the defective pipe or fitting and replace it with a sound one in a satisfactory manner.

D. The pipe and fittings must be thoroughly cleaned before they are laid and must be kept clean until they are accepted in the finished work. Care must be exercised to avoid leaving bits of wood, dirt, rock and other foreign particles in the pipe. If any such materials are discovered before the final acceptance of the work, they must be removed and the pipe and fittings replaced, if necessary. All pipes must be kept absolutely clean during construction and must be stopped off with night plugs at the end of each day's work.

E. Excavate pipe trenches as specified in Section 312310 – Excavation, Trenching and Backfilling (Utilities). Hand trim bottom of trench to six (6) inches below bottom of pipe.

F. Place and compact pipe bedding as specified in Section 312310 Excavation, Trenching and Backfilling (Utilities).

G. Keep trench bottom free from excess water. Groundwater or water from other sources must be removed as per Section 312319 – Dewatering Excavations. If the trench bottom is unsuitable for the pipes foundation, the kind of stabilization to be utilized will be ordered in writing.

H. If, in the opinion of the Commissioner, the Contractor has failed to obtain an acceptably dry trench bottom using conventional methods of dewatering, the Commissioner may order the Contractor to excavate below the intended grade and to place sufficient sub-grade material as may be suitable over the trench bottom in accordance with Section 312310 – Excavation, Trenching and Backfilling (Utilities).

3.06 LAYING PIPE

A. Lay pipe to line and grade in prepared bedding as indicated on the Drawings. The pipe must be properly secured against movement and pipe joints must be made in the excavation as required. Pipe must have compacted bearing along its entire length. When completed, the sewer must have a smooth and uniform invert.

B. The pipe laying must begin at the downstream end of the pipe. Install pipe so that bells and grooves are on the upstream end. Install vitrified clay pipe in accordance with the requirements of ASTM C12.

C. Prevent dirt, rock and other foreign particles from getting into the open end of the pipe and any pipe joints.

D. Clean interior of pipe of cement, dirt and extraneous material as the work progresses.

E. Lateral and service connections are to be made with manufactured wye fittings or preformed tapered holes or field cored holes. Openings for service connections are to be at an elevation between seven (7) feet and eight (8) feet below the ground grade.

3.07 DRAIN CONNECTIONS

A. Each slant, tapered hole or wye branch and new drain connection must be the same size as the existing drain or sewer unless otherwise shown on the Plans or ordered by the Commissioner.

B. If existing cast-iron drains are encountered which must be connected to the new sewers, the Contractor must furnish and place cast-iron pipe and fittings as required or as ordered by the Commissioner.

C. That portion of each drain connection and drain stack between the barrel of the sewer and the side of the trench must be encased and supported on a concrete or masonry pier as shown on the Plans, except that 8-inch drain connections from catch basins where such catch basins are located within the lines of the sewer trench must be supported on trench backfill. Drain connections constructed outside the neat lines of the sewer trench must be placed on a minimum of six (6) inches of granular embedment as described in Section 312310 – Excavation, Trenching and Backfilling (Utilities).

D. Drain stacks for future drain connections must have socket ends closed by suitable stoppers mortared in place.

E. The Contractor must examine all house drains, catch basin outlets and other existing drains or sewers to be connected to the new sewers, and if any such drain is found defective, as determined by the Commissioner, the Contractor must remove and relay the defective portions in accordance with the Specifications.

3.08 PIPE JOINTS

A. Pipe joints must be made secure and watertight.

B. Employ appropriate equipment to draw the sections of the pipe tightly together.

C. Apply lubricant to rubber gaskets immediately before joining pipe sections.

D. Joints of bell-and-spigot pipe and tongue and groove pipe must be filled with cement mortar so as to make a strong and watertight joint. Finish joints smooth on inside of pipe with cement mortar.

E. Inside joint recesses of pipe shall be filled with cement mortar prior to closure of the joint. After closure is made, the joint must be pointed inside of the pipe and excess mortar removed.

F. Inspect each joint for proper assembly prior to backfilling.

G. Mortar joints used for connections to existing sewer pipes or house drains may be used only when connections cannot be made using gasketed joints as specified or the appropriate pipe adaptor as supplied or recommended by the pipe manufacturer, or as directed otherwise by the Commissioner.

1. When mortar joints are required, they must be constructed to the following standards:
2. Center spigot of pipe in the socket using a packing gasket of twisted impregnated oakum of proper thickness and sufficient length to pass around the pipe and lap the top.
3. After the pipe has been placed, caulk the gasket into the annular space and fill the remainder of the space with Portland cement mortar beveled off with the outside of the socket.
4. Mortar for pipe joints or fittings must be made of one (1) part Portland Cement and one (1) part sand conforming to applicable requirements of Section 033000 – Concrete.
5. Only a sufficient amount of mortar may be prepared for use within forty-five (45) minutes of application. Any mortar that has begun to set must not be used.
6. As each joint is completed, thoroughly clean the inside of the pipe to remove all excess joint material.

3.09 CLEAN OUTS

A. Risers must be the same size as the pipe, and must consist of a wye or 1/8 bend extended to another 1/8 bend to the cleanout housing.

3.10 TEMPORARY BULKHEADS

A. At ends of constructed sections where adjoining mains or structures have not been completed and are not ready to be connected, construct temporary bulkheads.

3.11 SHORT TUNNEL CONSTRUCTION

A. Pipes to be placed in short tunnels must be jointed prior to being pulled into position. Pipe must be pushed or pulled into position in a manner arranged to keep joints tight and to prevent deflection.

3.12 ENCASING DUCTILE IRON PIPE IN POLYETHYLENE

A. Encase all cast and ductile iron pipe and fittings encased in polyethylene tubing.

3.13 SEPARATION BETWEEN WATER AND SEWER MAINS

A. When a sewer main crosses below water main and the vertical separation is between 18 and 6-inches, as measured between the bottom of the water main and crown of sewer pipe, the sewer must be constructed of ductile iron pipe with rubber gasketed joints to a distance one foot beyond the wall of the trench excavation. Flexible transition coupling must be used to join the ductile iron pipe to the sewer pipe and be encased in betonite as shown on the drawings.

B. When a sewer main crosses above a water main, the sewer pipe must be constructed of ductile iron pipe with rubber gasket joints for a perpendicular distance of 10 feet on either side of the centerline of the water main pipe, and an 18-inch vertical separation must be maintained. Flexible transition coupling must be used to join the ductile iron pipe to the sewer pipe.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The work of SEWER MAIN PIPE AND FITTINGS shall not be measured for payment.

4.02 PAYMENT

A. No separate payment shall be made for the work covered in this section. Payment for the Work of SEWER MAIN PIPE AND FITTINGS shall be included in the contract lump sum price as shown in the Schedule of Prices for CIVIL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 020000.

END OF SECTION 33 31 13

SECTION 33 39 13

SEWER MANHOLES, CATCH BASINS, INLETS AND SPECIAL STRUCTURES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes the requirements for constructing and/or adjusting of sewer manholes, electrical manholes, catch basins, inlets, junction chambers, tumbling basins, vaults, and other structures constructed of cast-in-place or precast concrete, or masonry structures shown on the drawings and specified here.

1.03 RELATED SECTIONS

A. Section 033000: Cast-In-Place Concrete.

B. Section 312310: Excavation, Trenching and Backfilling (Utilities).

C. Section 312319: Dewatering Excavations.

D. Section 330522: Repair and Adjustment of Sewer Mains and Structures.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM), latest edition:

1. STM A48 - Standard Specification for Gray Iron Castings.
2. ASTM A185 - Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete Reinforcement.
3. ASTM A197 - Standard Specification for Cupola Malleable Iron.
4. ASTM A536 - Standard Specification for Ductile Iron Castings.
5. ASTM A615 - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
6. ASTM C32 - Standard Specification for Sewer and Manhole Brick.
7. ASTM C55 - Standard Specification for Concrete Building Brick.
8. ASTM C139 - Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes.
9. ASTM C443 - Standard Specification for Joints for Concrete Pipe and Manholes Using Rubber Gaskets.

10. ASTM C478 - Standard Specification for Precast Reinforced Concrete Manhole Sections.
11. ASTM C857 - Standard Practice for Minimum Structural Design Loading for Underground Pre-cast Concrete Utility Structures.
12. ASTM C858 - Standard Specifications for Underground Precast Concrete Utility Structures.
13. ASTM C990 - Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants.

B. IDOT Standard Specification for Road and Bridge Construction (SSRBC), latest edition.

C. American Association of State Highway Transportation Officials, Standard Specifications for Highway (AASHTO), latest edition.

D. CDWM Regulations for Sewer Construction and Stormwater Management, latest edition.

E. ISPE Standard Specifications for Water & Sewer Construction in Illinois, latest edition.

1.05 SUBMITTALS

A. Refer to Book 1 for submittal requirements and procedures for Shop Drawings, Product Data, Records and Samples.

B. Shop Drawings: When not indicated on the Contract Drawings in sufficient detail or definition, submit detailed drawings of cast-in-place and precast concrete utility structures and related metal work.

C. Product Data: Submit manufacturers' product data for standard manufactured precast concrete sections and structures, for metal gratings and covers, and for other, related miscellaneous metal items.

D. Certification: Submit certification or other acceptable evidence that covers and grates to be provided for roadways and parking areas meet proof-testing requirements for AASHTO H2O traffic loading.

PART 2 - PRODUCTS

2.01 PRECAST CONCRETE STRUCTURES

A. Precast concrete base and riser sections furnished for manholes, valve basins, catch basins and other structures must conform to ASTM C478.

B. Furnish riser sections in various heights, including an offset tapered section, as detailed on the Drawings, or as directed by the Commissioner.

C. Precast reinforced concrete flat slab tops for manholes must conform to ASTM C857, and be designed to accommodate a minimum AASHTO loading of HS20, unless directed otherwise by the Commissioner.

2.02 JOINT SEALANTS

A. Rubber gaskets must conform to ASTM C443.

B. Preformed butyl rubber flexible rope type gaskets must conform to ASTM C990.

2.03 ADJUSTING RINGS

A. Adjusting rings are to be precast concrete with sufficient steel reinforcing to prevent cracking in normal handling and use.

B. Mating Faces: Must be smooth, parallel, free from cracks, chips, spalls or casting irregularities which interfere with creating a watertight mating surface between the adjusting ring and top of the utility structure.

1. Provide grooves in faces to contain extrudible preformed gasket material when applicable.

C. Adjustment rings shall not exceed two (2) rings, or a maximum of 8 inches.

2.04 CASTINGS

A. Iron castings are to be ductile iron castings conforming to ASTM A536, Grade 60-40-18, or gray iron conforming to ASTM A48, free from blowholes, shrinkage, cracks and other defects.

B. Allowance for shrinkage must be made in the patterns to meet the specified thickness. Frames and lids are to seat at all points.

C. Malleable castings are to conform to ASTM A197.

D. All castings are to be made accurately to dimensions shown on the plans, and planed, filed, or ground where otherwise necessary to secure flat and true surfaces.

2.05 STEPS

A. Aluminum alloy WP 6061 or WP 6063 conforming to ASTM B361. Coat the portion of aluminum step embedded in concrete and the portion extending two (2) inches beyond embedment with bituminous paint.

2.06 CAST-IN-PLACE CONCRETE

A. Concrete in accordance with Section 033000 – Concrete.

2.07 CONCRETE AND MASONRY BLOCKS AND BRICKS

A. Precast concrete brick must conform to ASTM C55 quality designated Grade N-1.

B. Sewer brick must conform to the qualifications for "brick for sewers or drainage structures", Grades SS or SM, as established in Table I of the current ASTM C32, except where modified here.

1. Brick must be uniform, sound, hard burned, of compact texture, free from lime and cracks with a clear ringing sound when struck, whole and with edges full and square, and of standard dimensions.
2. Brick, when thoroughly dried and immersed in water for twenty-four (24) hours, must not absorb more than 15% by weight of water.
3. If in any load of brick more than 10% are inferior, the whole load is rejected.
4. If in any load of brick less than 10% are inferior, the brick is accepted provided the Contractor pulls out all inferior bricks, and immediately removes them from the Site of the Work.

2.08 MORTAR

A. Mortar for brickwork is to be composed of one (1) part Portland cement and two (2) parts screened sand.

1. Portland cement must conform to the requirements of Section 1001 of the SSRBC.
2. Sand must be Class A quality and Gradation FA-9 as specified in Article 1003.02 of the SSRBC.

B. The cement and sand must be proportioned by volume and thoroughly mixed in a tight box.

C. After the initial mixing, water is to be added gradually and the ingredients mixed until the mortar is of proper consistency. The amount of water must be no more than necessary to produce a workable, plastic mortar.

D. Prepare only a sufficient amount of mortar for immediate use and any mortar that has begun to set must not be retempered or used in any way in the Work

2.09 REINFORCING STEEL

A. Reinforcing steel is to meet the requirements of ASTM A615, Grade 60 and A185 for wire fabric.

PART 3 - EXECUTION

3.01 GENERAL

A. Excavate, backfill and compact in accordance with Section 312310 -Excavation, Trenching & Backfilling (Utilities).

B. All brick must be thoroughly wetted immediately before being laid.

C. Old brickwork must be thoroughly cleaned and wetted before new work is jointed thereto.

D. No masonry work is to be done when the temperature is below 33º F unless otherwise approved, and then only under conditions for protecting it from frost.

3.02 PRE-CAST STRUCTURE INSTALLATION

A. Carefully place precast sections for all structures on prepared bedding so as to fully and uniformly support the structure and allow pipes to be laid to proper grade.

B. All lift holes on precast sections must be completely filled with mortar, smoothed on both inside and outside surfaces.

C. Seal joints between riser sections with approved mastic sealant or rubber gaskets, or as directed by the Commissioner.

D. Place one adjusting ring (only) on manhole top. Select thickness of adjusting ring to bring completed structure to required elevation.

E. Seal joints between adjusting rings and frames with approved mastic sealant before backfilling structures.

F. Install manhole frame and cover.

3.03 MASONRY STRUCTURE INSTALLATION

A. Install precast concrete or cast in place base as shown on the Drawings.

B. Thoroughly wet all brick immediately before laying.

C. Lay brick courses to the line, straight and parallel, breaking joints with those in adjacent courses.

D. Lay brick radially as headers in a full bed of mortar with joints not exceeding 3/8-Inch in thickness.

E. Fill joints with mortar. Interior joints must be trowel-struck.

F. Fresh masonry must be plastered inside and outside and must be protected from damage of all kinds.

G. New work, unless immediately covered with earth or brick backing, or an approved form of curing compound, must be kept moist until the mortar has hardened.

H. Install manhole frame and cover.

3.04 CAST-IN-PLACE CONCRETE STRUCTURES

A. Construct Cast-In-Place Concrete Structures in accordance with Section 033000 – Concrete.

3.05 FINAL ADJUSTMENT OF STRUCTURES

A. To prevent debris from entering the sewers, place 22 gauge galvanized steel plates beneath perforated lids of all structures prior to the placing of any type of surfacing. Maintain plates in place until the completion of all surface restoration.

B. After the base course and binder course have been placed, and prior to placing the surface course, the structures must be adjusted to match the final pavement elevation.

C. Remove the binder and base course adjacent to and for a distance not exceeding 12-inches outside the base of the castings.

D. Adjust the castings to final pavement elevation with adjusting rings set in mortar.

E. Fill the space around the casting with Class SI concrete to the elevation of the surface of the binder course.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The work of SEWER MANHOLES, CATCH BASINS, INLETS AND SPECIAL STRUCTURES shall not be measured for payment.

4.02 PAYMENT

A. No separate payment shall be made for the work covered in this section. Payment for the Work of SEWER MANHOLES, CATCH BASINS, INLETS AND SPECIAL STRUCTURES shall be included in the contract lump sum price as shown in the Schedule of Prices for CIVIL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 020000.

END OF SECTION 33 39 13

SECTION 34 11 93

MISCELLANEOUS TIMBER

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specifications Sections, apply to this Section.

1.02 SUMMARY

A. This Section specifies the requirements to furnish and install treated timber guard, footwalk decking, platform decking, station platform timber, footwalk ties, center planking, closure boards and other treated lumber required to complete the scope of work detailed on the plans and specified elsewhere. The Contractor will furnish all labor, tools, equipment and incidentals as necessary to install the required sizes and quantity of treated timber.

1.03 REFERENCES

A. The most recent version of each standard that relates to softwood lumber as follows:

1. AREMA – American Railway Engineering and Maintenance of Way Association.

2. AWPA – American Wood Preservers Association

3. SPIB – Southern Pine Inspection Bureau

1.04 SUBMITTALS

A. The Contractor will submit shop drawings and other appropriate documentation to the CTA for review and approval prior to the start of work to verify conformance with the Contract for the materials and the treatment required.

B. The Contractor will submit certification from the lumber mill that verifies the structural density of the material furnished and certification from the treatment plant that the lumber has been treated to the specific density required by Contract. The certification will be presented on each respective company's letterhead and signed by an appropriate representing officer of each company.

PART 2 – PRODUCTS

2.01 GENERAL

A. The Contractor will furnish and install all treated timber required for the completion of the work as shown on the plans and as specified herein.

B. All timber, planking and decking will be Southern Yellow Pine, Dense Structural Grade 65 or better.

C. The timber guard will not have gang nail plates or 's' irons installed on the ends.

D. All required fasteners will be galvanized in accordance with ASTM 153 D.

2.02 SEASONING

A. All artificial seasoning methods will be submitted to the CTA for review and approval prior to the start of work. The CTA will not consider extra Contract time or extra Contract cost for the Contractor if a method is not accepted.

B. The Contractor will employ adequate means and methods to minimize defects caused by the seasoning process.

C. The seasoning process chosen by the Contractor will ensure that the entire cross section of the timber is seasoned to be at or below a moisture content of twenty (20%) percent or less. It is suggested that the material should be air dried; however, various methods of artificial seasoning may be acceptable. The method of seasoning utilized must be submitted to the CTA for review and approval prior to the start of work. Documentation indicating that the Contractor has verified the moisture content of the lumber was as specified will be submitted for review and approval by the CTA prior to the start of work.

D. Incising of lumber is strictly prohibited.

2.03 PRESSURE TREATMENT

A. The Standard Rueping Process in strict conformance with the current AWPA C6 Cross Ties and Switch Ties-Preservative Treatment will be used to treat all miscellaneous timber included in this specification.

B. The preservative used will conform to current AWPA P2 Standard for Creosote Solution.

C. Retention and Penetration

1. The timber will be treated by an empty cell process to a minimum retention of eight (8 lbs/ft^3) pounds per cubic foot with AWPA P2-13 Creosote Solution.

2. The penetration will be a minimum of two and one half (2 1/2") inches or until ninety (90%) percent (89% to be verified) is penetrated.

D. All creosote treated lumber will be subjected to a steam treatment prior to the final vacuum treatment, after the creosote pressure treatment, to minimize dripping and bleeding of the preservative from the faces of the timber after installation. Ties will be clean and free of all dirt, debris and excess creosote.

2.04 DIMENSIONS

A. The timber guard will be sized six (6″) inches by eight (8″) inches and S4S. The eight (8″) inch dimension must be exact in order to comply with the CTA clearance diagram. The minimum length of timber guard will be no less than sixteen (16′) feet and no more than twenty-two (22′) feet.

B. The footwalk ties will be sized six (6″) inches high by six (6″) inches wide in tangent track sections and six (6″) inches high by four (4″) inches wide in curved track sections. Lengths indicated on the Contract Drawings and shaped as shown on the plans. All timber in this section will be full size and surfaced S4S.

C. The footwalk decking, track planking, track access platform closure boards, station platform decking and wayside platform decking will be a nominal two (2″) inches high by six (6″) inches wide. All decking and planking boards will be furnished in lengths of thirty (30″) inches, eight (8′) feet, twelve (12′) feet, or sixteen (16′) feet lengths as shown on the Contract Drawings. The various lengths will be furnished to minimize field cutting of the timbers.

D. Footwalk decking stringers will be four (4″) inches high by six (6″) inches wide turned on edge.

E. The station platform closure boards will be a nominal two (2″) inches high by ten (10″) inches wide. The station closure boards will be furnished in lengths of eight (8′) feet, twelve (12′) feet, or sixteen (16′) feet lengths. The various lengths will be furnished to minimize field cutting of the timbers.

2.05 FINISH

A. No gang nail or ‘s’ irons will be installed on any timber furnished under this specification.

PART 3 – EXECUTION

3.01 TIMBER GUARD

A. The timber guard will be furnished and installed with the eight (8″) inch side vertical and lagged into each tie, with a twelve (12″) inch copper bearing steel lag screw, in a serpentine pattern as shown on the plans. For timbers where the heart is not centered, the bark side will be installed upward. For timber guard with vertical grain the bark side will be installed toward the field side of the track.

B. When installed in curve locations, the timber guard will be sliced vertically every two (2′) feet through the piece on the compression side of the timber in order to allow for the timber to be bent and conform to the curved track geometry detailed on the plans.

C. When the timber guard is modified for a curve, if the cut is deep enough to expose the untreated portion of the tie, then copper naphthenate will be used to treat the exposed un-treated wood and non-hardening roof cement will be used to cover the exposed un-treated wood to prevent moisture from entering the exposed interior timber.

3.02 PLATFORM AND FOOTWALK DECKING

A. In all locations for all wood furnished and installed, when the grain is flat, the bark side will be installed upward all of the time. For vertical grain pieces the bark side will be installed toward the base of rail. Failure to comply with this directive will result in replacement of all wood improperly installed with new wood at no change in Contract time and no change in Contract cost considered.

B. All boards will be installed with the entire piece fully treated. Cut ends must be minimized. Untreated ends must be suitably treated with an acceptable product. Copper Napthenate is suggested. The treatment product will be submitted for review and approval by the CTA. The treatment product will be considered incidental cost to the Contract and the application will be done at no change in Contract time and no change in Contract cost.

C. Track planking, wayside platform decking and footwalk decking will be installed with one half (1/2") inch gaps.

D. Wayside platform decking will be installed with a 1/8 inch between deck boards to allow for air circulation, drainage and expansion.

E. All planking and platform decking will be installed using twenty (20d) penny, spiral shank, hot dipped galvanized deck nails. All nails will be driven at a slight angle from perpendicular. Nails found driven perpendicular will be removed and the entire board replaced at no change in Contract time and no change in Contract cost.

3.03 FOOTWALK SUPPORT

A. Footwalk supports will be installed using hot-dipped galvanized metal clips and straps as shown on the Contract Drawings. Clips will be of a type that prevents uplift of the footwalk.

B. Each end of each support timber will fall within one (1") inch of the centerline of that tie.

C. Raised decking around special trackwork will be supported on nominally sized four by six (4"x 6") inch timbers.

D. When the raised center footwalk crosses an expansion device, the footwalk support ties will be directly fixed only on the side of the fixed track structure. Footwalk support ties that span across a cross girder from the expansion side, will not be directly affixed to the support tie. In this instance it is imperative that the support sits directly over the center of the tie. In this instance there will not be a two (2") by six (6") inch board installed across the gap between the footwalk support ties; however, in every other instance a two (2") by six (6") inch board will be installed to cover the gap.

PART 4 – QUALITY CONTROL AND INSPECTION

4.01 Treatment penetration will be determined by destructive testing using bored cores taken from the center of no less than three (3) randomly selected pieces of timber guard from each five hundred (500) piece lot of material treated. If the borings meet the penetration requirement, with no single reading below two (2") inches, the lot will be accepted.

A. Core holes will be saturated with the creosote coal tar solution prior to the insertion of plugs.

B. Core holes will be fitted with tight, treated plugs after sampling.

C. Timber failing to meet the penetration requirement may be retreated and re-tested at the Contractor's option.

D. Cores will be furnished to CTA for review and approval prior to the start of work.

4.02 All sections furnished smaller than the timber guard will have (3) three randomly selected pieces from every five hundred (500) pieces treated that will be sawn in half to reveal the full penetration of creosote. A four (4") inch length of those pieces will be submitted to the CTA for review and approval prior to the start of work.

4.03 The treatment plant will submit the test samples under a cover letter of certification that the samples are representative of the full quantity of material furnished. The certification will be signed by an authorized officer of the company.

PART 5 - MEASUREMENT AND PAYMENT

5.01 MEASUREMENT

A. The work for MISCELLANEOUS TIMBER shall not be measured for payment.

5.02 PAYMENT

A. No separate payment shall be made for work covered in this section. Payment for the Work of MISCELLANEOUS TIMBER shall be included in the contract lump sum price as shown in the Schedule for Prices for TRACKWORK.

5.03 PAY ITEM ACCOUNT NUMBER

A. Trackwork: 340000.

END OF SECTION

SECTION 34 21 01

GENERAL REQUIREMENTS FOR TRACTION POWER EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 DESCRIPTION

A. This section sets forth the conditions and technical requirements for the installation of traction power equipment.

B. Installation of traction power equipment shall include designing, manufacturing, testing, delivering, installing and commissioning the following:

1. 15kV ac switchgear assemblies
2. Self cooled, dry type, indoor or outdoor rectifier transformers
3. Natural convection air cooled rectifiers
4. 800 volt dc switchgear assemblies
5. Anode bus duct
6. Negative equalizer bus and drainage board
7. Station batteries, battery chargers, distribution panel board for 125 volt dc control power and accessories
8. Telephone line sharing switches, Model M-394-B-01 (A-Star Electric), one for each substation
9. Communication Cabinet
10. RTU Cabinet

1.03 DESIGN AND PERFORMANCE

A. General:

1. 15kV ac switchgear line-ups, rectifier transformers, rectifiers and dc switchgear line-ups specified herein and shown in single line diagrams of the Contract Drawings, shall function as a complete coordinated package for normally unattended operation of the Authority's system. All components shall be sized and selected for safe, reliable operation. All material and equipment furnished shall be of the highest quality material, design, and workmanship.
2. The substation building design requires that 15kV switchgear line-up, rectifier transformers, rectifiers and 600 volt dc switchgear line-up specified herein shall

be designed in such a manner as to permit easy installation for the equipment arrangement indicated on the Contract Drawings. It also sets forth certain limiting area dimensions which shall be maintained for the Authority's usage exclusively and minimum clearance as required for Authorities safe operation.

3. All substation equipment shall be shipped in the largest assemblies which can be brought in through the equipment door and passage as shown on the drawings. Equipment dimensions shall be such that any piece can be removed from the building through this same door or passage in the future without dismantling other equipment. Final arrangement of equipment and manner of assembly and disassembly will be subject to the approval of the Authority.
4. The 15kV switchgear is an integral part of ComEd Company's 12,600 volt distribution system. The supplied 15kV ac switchgear shall be subject to approval by ComEd Company for this service.

B. Service Conditions:

1. The ac switchgear line-ups, rectifier transformers, rectifiers and dc switchgear line-ups herein will serve as supply for the CTA's rapid transit system in parallel with the existing traction power equipment installed at other locations. Individual rectifier load can be expected to vary from a 15 second peak near 450 percent full load current rating during peak periods to a 30 minute near zero current during off-peak periods. High voltage spikes of either polarity from train operations may be transmitted to these substations through the interconnected-systems.
2. The ac supply for the rectification equipment will be taken directly from ComEd Company's 12,600 volt, 60 Hz, 3 phase ac system. Ultimately the X/R ratio is expected to be 15 and the interrupting capacity 500 MVA. Supply voltage at the ac switchgear bus in the substation can be expected to vary between a minimum of 10,800V ac and a maximum of 13,500V ac.
3. While it is not expected that this installation will present any harmonic or telephone interference problems, should such problems arise in the rectification equipment, Contractor shall give immediate and full engineering support in determining proper corrective measures including, preparation of the Specifications for additional equipment required, if any. The cost of these services shall be borne by the Contractor.
4. The noise level at any and all points, three feet from any and all of the equipment in the building covered by this Specification with any and all equipment energized for normal service, but with rectifiers unloaded, shall not exceed the following values:

	Octave Band	
a.	20 – 75 Hz	80 dB(A)
b.	75 – 150 Hz	75 dB(A)
c.	150 – 300 Hz	75 dB(A)
d.	300 – 600 Hz	72 dB(A)
e.	600 – 1200 Hz	68 dB(A)
f.	1200 – 2400 Hz	65 dB(A)
g.	2400 – 4800 Hz	55 dB(A)
h.	4800 – 10000 Hz	45 dB(A)

C. Proposed Control and Supervision:

1. The rectification equipment specified herein will normally be in continuous service. However, they shall be provided with control and supervision features such as to safeguard the various equipment and to permit both local and/or supervisory control.

   a. The control schematics included in this Specification must be strictly adhered to. Deviations, if any, will not be permitted unless approved by the Authority.
   b. Remote control panel to be added away from switchgear in parallel with regular controls.

2. Not all devices referred to are to be supplied under this specification nor are all devices to be furnished herein listed. These devices have been included in the discussion hereinafter so that the Contractor can have a better understanding of the integration of the equipment supplied with the overall control and supervision scheme. The actual equipment to be supplied under this Specification is listed herein. For purposes of this discussion, the following device numbers shall be used hereafter:

DEVICE NO.	FUNCTION
1	Local control switch (START-STOP-PULL TO LOCKOUT).
3	Checking of interlocking relay
4	Master control relay.
4X	Auxiliary master control relay
8	DC control power breaker or switch
26D1	Positive rectifier bank over temperature device – first step
26D1A	Negative rectifier bank over temperature device – first step
26D	Positive rectifier bank over temperature device – second step
26DA	Negative rectifier bank over temperature device – second step
26H	Rectifier over temperature detector positive or negative heat bank
26X	Auxiliary relay to 26D and 26DA
27B	Bus Under-voltage Relay 27
27L	Line Under-voltage Relay 27
27BC	Battery charger failure relay
30	Rectifier annunciator
32	Reverse current trip device

32P	Polarizing coil for dc reverse current trip
33B	Breaker truck position switch
33R	Rectifier compartment door position switch
33T	Rectifier transformer equipment door position switch
43	Rectifier permissive control switch (REMOTE-LOCAL)
49T	Transformer winding over temp. device, first step
49TH	Transformer winding over temp. device, second step
52	Rectifier ac breaker
52/CS/C	Rectifier ac breaker control switch - CLOSE
52/CS/T	Rectifier ac breaker control switch - TRIP
52M	Rectifier ac breaker control switch – spring charged motor
52/TC	Rectifier ac breaker shunt trip coil
52/TI	AC breaker position switch - truck interlocking
64C	Rectifier ground relay, hot structure
64X	Rectifier ground relay, grounded structure
69	Breaker permissive control switch
72	Rectifier dc breaker
74	Trouble alarm relay
83	AC transfer switch
86	Lockout relay
86X	Conditional lockout relay
89N	Rectifier negative disconnect switch
95X, 95Y	Blown diode fuse indicator
99Y	Surge protection indicating relay
108	DC control power switch
108X	DC control power switch, load measuring.
124	Bus tie ac breaker
129	Contactor for load measuring resistor
130	Station alarm annunciator
143	Incoming Line and Tie breakers permissive selector switch (AUTOCLOSE-OFF)

150	Impulse tripping relay
152	Incoming line ac breaker
164C	DC switchgear ground relay, hot structure
164X	DC switchgear ground relay, grounded structure
169	Permissive control switch (REMOTE LOCAL)
172	DC feeder breaker
172Y	DC feeder breaker auxiliary relay
172Z	DC feeder breaker auxiliary relay
174	Station trouble alarm relay
176	Direct acting series trip device
182	Solid state dc reclosing relay
182X	Load measuring device auxiliary relay
183	Voltage measuring relay
186	DC feeder breaker cumulative lockout timing device
201	Supervisory close relay
201D	Feeder Breaker Emergency Close
201X	Feeder master relay indication relay
237	SCADA loss of dc backup supply
243	Supervisory control switch
269	Permissive control indication relay
283	SCADA loss of ac
286	Supervisory lockout relay
294	Supervisory trip relay
451	Microprocessor relay for directional overcurrent protection. Positive-sequence voltage-polarized phase directional element with memory for directional stability during phase faults. Ground, multiple phase, negative-sequence, neutral, and residual instantaneous line protection definite-time overcurrent elements with independent pickup time dial. (Line Protection and Bus protection))
551	Microprocessor relay for comprehensive overcurrent protection. Phase negative-sequence, residual ground, and neutral overcurrent protection in a compact package. Complete set of instantaneous, definite-time, and time-overcurrent elements.

(Transformer and bus protection)

EC Emergency close relay in RTU cabinet

SD Smoke detector

3. Starting of rectifier shall be accomplished by energizing 4X. This shall be accomplished locally by operation of control switch 1 or remotely by supervisory control through operation of 201 or control switch 1 in remote position and the other rectifier of the substation tripped. The following shall prevent energization of 4X:

   a. Loss of control voltage
   b. Energization of 86 or de-energization of 86X
   c. Remote lockout through operation of 286
   d. Local operation of 1 to the PULL TO LOCKOUT position

4. Operation of 43 to the local position shall prevent energization of 4X except through operation of control switch 1.
5. Shut-down of rectifier shall be accomplished by de-energizing 4X. This shall be accomplished locally by the operation of control switch 1, automatically by the operation of 4 or loss of control voltage and remotely by supervisory control through operation of 286 or 294. The rectifier shall be shut-down by the operation of any of these devices regardless of the position of 43.
6. Energization of 4X shall cause 48 and 62T to time and closure of 52. Closure of 72 shall follow closure of 52 and operation of 62T. If the ac breaker-52 does not close within 5 seconds, 62T will time out and block the closure of dc rectifier breaker 72. Failure of 72 to close and remain closed within a normal length of time shall cause 48 to operate which shall result in lockout. Operation of 43 to LOCAL position will prevent operation of 48 as described above.
7. De-energization of 4X shall cause opening of 52, 72, and shut-down of that rectifier unit.
8. The following safety devices shall operate 86 and cause shut-down of the rectifier until 86 is hand reset. This type shut-down is termed LOCKOUT. (Loss of ac control power shall not cause operation of any of these devices):

   a. Open door on rectifier diode negative switch compartment and positive 600V bus compartments (Device 33) or open enclosure on transformer.
   b. Bus Undervoltage (Device 451).
   c. Equipment overload detected by ac relays (Device 551).
   d. Insulation failure between rectifier components and enclosure (Device 64C).
   e. Incomplete starting sequence (Device 48).
   f. Rectifier negative disconnect switch open. (Device 89N).
   g. Supervisory (Remote) control lockout (Device 286).
   h. Rectifier reverse current (Device 32).
   i. Failure of two diodes (Device 95X).

9. The following safety devices shall cause operation of 86X and shut-down of the rectifier until the condition is corrected. This type shut-down is termed CONDITIONAL LOCKOUT.

a. Rectifier second step diode heat sink temperature (Devices 26D and 26DA).
b. Transformer second step high winding temperature (Device 49TH).
c. Loss of ac power (Device 27).

10. The following safety devices shall activate the device 74 and cause a TROUBLE ALARM only until the condition is corrected.

a. Transformer first step high winding temperature (Device 49T).
b. Rectifier first step high diode heat sink temperature (Devices 26D1 and 26D1A).
c. Insulation failure between rectifier enclosure and ground (Device 64X).
d. Rectifier surge diverters' failure (Device 99Y).
e. Loss of one diode. (Device 95Y).

11. Local supervision shall be provided on each rectifier control cubicle in the form of a back lighted window annunciator (Device 30) to indicate operation of all safety devices listed in Subsections C.8, C.9 and C.10 above, and other power rectifier criteria as may be deemed essential by the rectification equipment Contractor. Audible alarm for annunciator shall be operable only when 43 is in LOCAL position.
12. Supervisory control will be provided to permit remote control and supervision of the following items. The Contractor shall furnish and connect the necessary contacts to terminal boards.

a. Incoming line breakers (Device 152) (Devices 201 and 294 for control and Device 152 for monitoring).
b. Bus tie breaker (Device 124) (Devices 201 and 294 control and Device 124 for monitoring).
c.
d. Start and shut-down of each rectifier (Devices 201 and 294 for control and 4X for monitoring).
e. Lockout shut-down of each rectifier (Device 286 for control and 4 for monitoring).
f. DC feeder breakers (Device 172) (Devices 201 and 294 for control, and 201X and 172 for monitoring).
g. Emergency close of dc feeder breakers (Devices 201 and 201D for control, and 201X and 172 for monitoring).

13. The supervisory shall be provided to permit remote supervision of the following items. The Contractor shall furnish and connect the necessary indicating contacts to terminal boards.

a. Rectifier dc breaker (Device 72).
b. Rectifier ac breaker (Device 52).
c. Trouble alarm (Device 74).
d. Positions of permissive control switch (Device 43 for monitoring).
e. Local supervision shall be provided on each dc switchgear auxiliary cubicle door in the form of a back lighted window annunciator, with minimum of twenty-four (24) windows (Device 130) to indicate the operation of SCADA cut-off switch, hot and grounded dc switchgear enclosure

(separate points), auxiliary power transfer switches, line-1 and line-2 under voltage, loss of dc power in SCADA, battery voltage and other common functions of the Substation (Station alarm) (Device 174 for monitoring). Each of these annunciator points shall be equipped with an independent contact for auxiliary output. This contact shall open and close to follow field contact wired to terminal blocks for connections to SCADA RTU (See Section 34 21 05 for detail description).

14. The supervisory control shall be provided to permit remote telemetering of the following items:

    a. Output current of each rectifier continuously (current transducer for signal).
    b. Total substation output current continuously (sum of rectifier transducer outputs for signal).
    c. DC bus voltage continuously (dc voltage transducer for signal).
    d. DC feeder voltage and current of each feeder continuously (dc voltage and current transducers for signal).
    e. AC bus voltage and ac line current of each ComEd line.

D. Protective Device Coordination:

1. The Contractor shall perform a relay coordination study and shall furnish protective devices in the traction power rectifier equipment as listed elsewhere in this part of Specification, or as may be required, to provide reliable coordinated protection for the system. All such devices shall be adjustable and shall be factory calibrated to provide the following general protective scheme.
2. Using protective devices on ac switchgear.

    a. Pick-up of directional relay to trip ac incoming line feeder breakers on the faulted side of the incoming 12,600V ac line. (Device 451).
    b. Pick-up of instantaneous element on short time relay to trip rectifier ac breaker for 12,600V ac circuit and rectifier transformer faults. (Device 551-T).
    c. Pick-up of short time relays to trip rectifier ac breaker for rectifier transformer secondary and/or 600V dc feeder breakers for faults on dc feeders. It shall also provide coordination with the reverse current trip on the dc breaker of any one other rectifier operating in parallel (see Section 16605). (Device 551-T)
    d. Relay pick-up time shall not be less than 7 cycles. (Device 551-T).
    e. Approximately 15 seconds pickup of long time relays to trip rectifier ac breaker at 450 percent rectifier full load current (Device 551-T).
    f. Approximately 60 seconds pickup of long time relays to trip rectifier ac breaker at 300 percent rectifier full load current (Device 551-T).
    g. Two hours of long time relays to trip rectifier ac breaker at 150 percent rectifier full load current. (Device 551-T).
    h. Programming/setting of all protective devices shall be performed by SEL trained and certified personnel.

3. Using protective devices on dc switchgear:

a. Pick-up of reverse current device to trip rectifier dc breaker for rectifier internal faults (Device 32). Coordination of protective devices shall prevent tripping of ac breaker on any rectifier operating in parallel for this condition (see Section 800 Volt DC Switchgear).
b. Pick-up of adjustable polarized discrimination and instantaneous trip devices to trip dc feeder breakers for dc feeder faults. The discriminating trip device shall have operating characteristics and adjustable ranges such as to trip for remote short circuits on the rails and discriminate against tripping for inrush on starting of trains insofar as possible. The instantaneous trip devices shall have operating characteristics such that ac breaker tripping shall not occur on dc feeder faults (Devices 150 and 176).
    1) Load measuring and automatic re-closing features on dc feeder breakers will cause automatic re-closure as soon as the condition that caused tripping is corrected.

4. Using temperature devices on rectifier transformer:

    a. Conditional lockout of rectifier following 150 percent of rectifier full load current for approximately 2 hours (Device 49TH).

5. Using protective devices on rectifier:

    a. Individual current limiting fuse in series with each parallel silicon rectifier element to open for element failure. Provide indicating lamps and diode fuse monitor relays as may be required to indicate failure of either element or fuse.
    b. Pick-up of thermal switches on heat sinks to trip associated ac and dc circuit breakers on heat sink high temperature due to any combination of excessive ambient temperature, reduced heat sink efficiency or excessive base load and load current including short circuits, that would result in failure of rectifier elements and/or fuses before other protective devices on ac and dc switchgear could operate (Device 26D).

E. Relays and Devices:

1. The type of relays and devices used in the control and supervision of the supplied equipment shall have proved successful in similar application over at least a 5 year period of use.
2. All control and instrument switches shall be rotary type provided with properly designated black escutcheon plates, clearly marked with white letters to show operating position. Breaker control switches shall be spring return. Instrument switches shall have an "OFF" position. Handles shall be solid colored plastic, or approved equal. Selection of operating handles shall be as follows:

    a. Breaker Control Pistol grip, black
    b. Permissive Control Oval, black
    c. Instrument Knurled round, black
    d. Pistol grip control switches shall be G.E. type SBM or approved equal

3. All control and auxiliary relays shall be suitable for use in switchgear equipment as defined in the latest issue of ANSI C37.90. Operating coils for direct current relays shall be suitable for continuous operation between 90 volts and 145 volts dc and alternating current relays between 85 percent and 110 percent of nominal rating.
4. All indicating lights shall be LED high output and shall operate with sufficient intensity between 90-145 volts dc. LED shall be visible under 50 fc operating floor lighting and shall not suffer premature failure from battery float or equalize voltage. LED samples of all colors used shall be furnished to CTA for evaluation and approval, prior to installation on the equipment.
5. All indicating instruments shall be semi-flushed mounted and shall have metal scales with black figures on a white background. They shall be approximately 4-1/4 inch in size, have taut band suspension, and be of 250-degree scale design.
6. DC control power for each circuit breaker cubicle in 15kV ac switchgear line-up and in 800 volt dc switchgear line-up shall be provided through sub dc distribution panels. These will be located in the tie breaker cubicle for the ac switchgear line-up and in the auxiliary cubicle for the dc switchgear line-up. A separate circuit breaker from the sub dc distribution panels shall be assigned for the control, tripping, metering and relaying circuits of each breaker cubicles of ac and dc switchgear line-ups.
7. The sub dc distribution panels shall be rated for 125 volt dc supply for a 2 wire system with a short circuit rating of 10,000 amperes. The circuit breakers shall be 30 amperes, 2-pole thermal magnetic type. The main bus shall be rated at 100 amperes copper sized in accordance with UL Standard. The construction of the panels shall be similar to ones described in Section "DC Distribution Panel" of this specification.
8. All fuses and disconnect switches for ac and dc control circuits shall be manufactured in the United States and shall be located in such a position that they are easily and safely accessible. In dc switchgear cubicles, all 600 volt fuses shall be mounted in enclosed fuse blocks and installed in the rear compartments. Minimum current interrupting capability shall be 20,000 amperes at 1000 volt dc, with an L/R ratio of 0.05 sec. Minimum voltage rating shall be 600 volt dc for 125 volts and below. All control and monitoring circuits connected to 600 volt dc system shall be rated 1000 volt dc.
9. All devices such as fuses, meters, relays, switches and lamps shall be suitably identified by plastic tags with black letter on white background and device symbol, and in case of fuses, rating and circuit feed. Identify polarities of fuses and switches. The tags shall be mounted under device with machine screws. Use of self trappings screws, rivets or adhesives will not be permitted.
10. Each circuit and panel-mounted device shall have a suitable processed plastic nameplate with black letters on white background for proper identification. Nameplate shall be of 1/16 inch thickness and type for specific use and shall be smooth with 0.003 inch Melamine covering as manufactured by Duralith Corp., or approved equal. Each circuit nomenclature will be specified later. Lettering shall be 1/4 inch in height where possible. The nameplates shall be mounted with machine screws. Use of self tapping screws, rivets or adhesives will not be permitted.
11. Approved tags, identifying dc feeder breaker sections, rectifier dc breakers, ac switchgear units, rectifier transformers and rectifiers shall be provided. Front and back tags for dc breaker sections, rectifier dc breakers and rectifiers shall

be 14 inches by 6 inches by 1/8 inch, 3 layers plastic with sunlight yellow surface color on both sides and black center core (black lettering). Front and back tags for ac switchgear units and rectifier transformers shall be 17½ inches by 3½ inches by 1/8 inch, 3 layers plastic with cardinal red surface color on both sides and white

12. center-core (white lettering). The letter size and nomenclature shall be as shown on the Authority's standard drawing. The tags shall be mounted with machine screws. Use of self tapping screws, rivets or adhesives will not be permitted.
13. Adjustable lugs on tubular resistors of 1.125 inches diameters shall be Ohmite Manufacturing Co., double-thumb screw adjustable lug, Catalog No. 2160, or approved equal. Adjustable lugs on tubular resistors of 0.438; 0.563; 0.750; 1.500; 1.625 and 2.500 diameters shall be Ohmite silver contact, bake-lite knob type Catalog Nos. 2163, 2165, 2167, 2183, 2187 and 2191 respectively, or approved equal. Adjustable lugs of .313 diameter shall be Ohmite silver contact screw driver type catalog No. 2161, or approved equal.
14. Rectifier annunciators (Device 30) shall be of the back lighted window type Seekirk A1600 series or approved equal.
15. All terminal blocks shall be heavy duty Marathon series 1500, GE type EB-5 or approved equal.
16. All control switches shall be pistol grip GE type SBM, Electro Switch, or approved equal.

F. Miscellaneous:

1. Bolted joints of current carrying members shall be provided with proper spring tension devices to maintain proper joint pressure under load (heat) cycles. For copper to copper joints use Everdure hardware or approved equal, for aluminum to aluminum joints use Belleville washers or approved equal.
2. Copper to aluminum bolted joint shall not be allowed.
3. Cable and control wires shall be copper, and shall meet the requirements of the Chicago Electrical Code.
4. Wiring shall be clearly identified using white plastic slip-on markers with etched black lettering. The marker diameter shall be consistent with the wire diameter to insure a snug fit, but yet able to be rotated for identification.
5. Device layouts shall provide safe visibility and easy access to all terminal blocks, fuses, switches relays, other miscellaneous devices and their associated wiring without reaching into blind spots and/or physically climbing into the enclosure. All devices such as fuses, switches, terminal blocks, etc. shall be mounted within 18 inches from the face of the cubicle, accessible for operation and maintenance. All fuses and disconnects shall be mounted in rear cubicles. Any device layout which is judged not to be safely maintainable will be rejected.
6. Serviceability under NFPA70E rules shall be taken into consideration for equipment layout with the intent of minimizing arc blast exposure and protective clothing requirements. Furthermore, all equipment shall have appropriate arc blast warning labels attached.
7. Transducers shall be fused separately.
8. Equipment enclosures shall be fabricated in such fashion as to provide sturdiness, durability and neat appearance. Structures shall provide adequate rigidity to prevent warping, bonding and vibration of panels and doors. Where required, heavier gauge metal and/or extra stiffeners shall be used to insure

that doors, panels and appurtenant mountings do not bend or rattle when being accessed for maintenance or, in case of breaker cubicles, when breakers are opened or tripped.

9. Equipment dimensions on drawings will be shown in U.S Standard System in feet and inches (non-metric scale).
10. Wiring terminals shall be ring style compression type.

1.04 RECTIFICATION EQUIPMENT DRAWINGS AND DESIGN CONFERENCE

A. Bidder shall submit with the proposal a statement that the equipment to be furnished will not exceed the dimensions shown on the Contract drawings. This shall be in the form of a signed letter on a company letterhead.

B. Schematic and wiring diagrams shall be prepared utilizing ANSI-IEEE standard device symbols and nomenclature as defined and listed in IEEE Standard C37.2 except where specified otherwise herein. Terminals and terminal block studs shall be clearly marked on all equipment and the markings shall agree with the drawings. All components on the drawings shall be marked to indicate size and rating.

C. All diagrams, drawings and instruction material shall be prepared utilizing the latest issue of AutoCAD in English language and U.S. Standard system of weights and measures. All drawings shall be 24 inches x 36 inches overall. The equipment layout drawing shall be drawn to 1/4 inch = 1 foot-0 inch scale. A bar chart (graphic scale) shall be provided on all equipment layout drawings.

D. The equipment manufacturer shall start detail design and drafting work for all equipment immediately upon Award of the Contract and shall process design work to completion without delay and without regard to normal manufacturing schedule, to permit timely rectification equipment installation.

E. Within fifty (50) days after Notice to Proceed, there shall be a design conference at the equipment manufacturer's facility, which shall be attended by CTA' personnel and their authorized agents. A sample agenda for the design conference has been included as Appendix G of the specification.

F. During the Design Conference the Contractor shall provide the following:

1. Certified-outlined dimensions and weights of all major items of equipment, namely:

   a. 800 Volt DC Switchgear

2. A list of any and all items the Contractor proposes to substitute for items listed in the Specification. Each proposed item of substitution must be supported by the following information:

   a. Device name, catalog number, and device number as shown on the Contract Drawings.
   b. Technical and descriptive literature of device.
   c. Schematic diagram of device down to component level.

d. Reason for substitution.

3. Outline of all tests to be performed in his factory or in factory of his supplier.
4. Name of testing laboratory which will perform the tests that cannot be conducted in the Contractor's or the Contractor's Supplier's factories.
5. Legitimate cause of request for the extension of any test report which cannot be submitted within thirty (30) days after the day the test is performed.
6. A list of all problems or conditions which require clarification.
7. The Contractor shall post on CTA's management web site as well as submit six (6) copies for the CTA's approval, the detail minutes of the design conference including all the documents that were submitted by the Contractor during the design conference.

G. Design Conference Cost:

1. Any transportation (air-coach class, and any other necessary) and first class lodging required outside the Chicago Metropolitan area by the CTA personnel, their authorized agents, or their authorized consultants and a representative from CPM, which are necessary to accomplish the satisfactory inspection of this Contract shall be paid by the CTA and not be included in the bid price. It is anticipated that one trip for 7 persons and lodging for 5 days and 4 nights will be required for conference.

H. Shop Drawings:

1. Post on CTA's project management website as well as submit six (6) copies of each of the following drawings to the CTA's for review after award of the Contract as scheduled hereinafter. The CTA's review will be general and will in no way relieve the Contractor from fulfilling all of his obligations and/or guarantees. All equipment outlines, plans and section drawings shall be drawn to scale.
2. Within fifty (50) days after Notice to Proceed:

a. Certified outline drawings indicating overall dimensions, aisle space requirements, location of control and protective devices on panels, and reference tables to furnished.
b. Certified floor plans showing dimensions necessary for installing equipment, equipment base details, and entrance available for main and control cables.
c. Certified section views of each non-identical unit showing bus and equipment locations and location of outgoing power and control terminals. Drawings must be in sufficient detail to illustrate accessibility for maintenance and for adjustments while energized.
d. Single line diagram showing all main connections and protective devices, and the location of all current, potential, and auxiliary devices, with the devices energized by them.
e. Schematic diagram of transformer, rectifier, ac and dc circuit breaker controls and alarms - these shall include ac schematic and dc elementary diagrams of all circuits.
f. Internal connection diagram of devices (as may be shown separately).

g. External wiring diagrams for all the equipment furnished for all the Traction power substation work.
h. Time vs. current curves for all ac and dc breakers.

3. Within thirty (30) days after return of schematic diagrams marked "Approved", "Approved as Noted", and "Revised and Resubmit" the Contractor shall resubmit the revised drawings, including:

a. Connection diagrams of each non-identical unit showing the following:
1) Internal wiring.
2) Terminal arrangement and marking for each outgoing power and control terminal.

b. Interconnection wiring diagrams showing the external connections between each piece of equipment furnished for the traction power substation work. Interconnection wiring diagrams shall show the terminal blocks of each individual unit and interconnection of each piece of equipment. The interconnection wiring diagram and the wire shall be identified with the wire color, the cable number, destination location and terminal block number, wire identifier and originating terminal block number.
c. Equipment nameplate data.
d. Instrument transformer ratio, phase angle and excitation characteristic curves.

4. Protective Device Coordination Curves.

a. Coordination curves shall be submitted electronically within 120 days after notice to proceed, showing relay and direct acting trip device coordination for all equipment furnished hereunder.
b. Coordination curves shall include plot of rectifier design capability and shall clearly indicate actual margin of coordination (from breaker trip to design capability) at each of 150 percent, 300 percent and 450 percent full load current and short circuit, taking into account aerating due to current imbalance and loss of one leg in each phase.
c. Final coordination will be subject to the Authority's approval.

I. After final review, and prior to the construction, of all drawings in the latest issue of AutoCAD format diagrams, material lists, recommended support parts shall be issued for the construction.

J. Test Costs:

1. Prior to shipping of equipment, numerous factory tests will be required as covered in Sections 34 21 11, "Traction Power Equipment Testing" and 34 21 12, "Traction Power Inline Test on Rectification Equipment" of the Specification.
2. Any transportation (air-coach class, and any other necessary) and first class lodgings required outside the Chicago Metropolitan area by the Authority's personnel, their authorized agents or their authorized consultants which are necessary for testing and to accomplish the satisfactory inspection of this

contact shall not be included in the bid price. The cost of witnessing the initial tests will be paid by Authority.

3. Following is the anticipated number of personnel and length of lodging for the tests:

Test	Number of Personnel	CTA Lodging Days
DC Breakers	5	3

4. If additional trips are required due to problems developed because of the negligence of the Contractor, the cost of those trips shall be borne by the Contractor.

1.05 EXPERIENCE

A. The Contractor shall submit sufficient evidence that the equipment manufacturer has a minimum of 5 years current experience in the successful manufacture of silicon rectifier conversion equipment for rapid transit substation systems and equal experience as prime equipment Contractor for rapid transit conversion substation systems, or the Contractor shall demonstrate, to the satisfaction of the Authority, that he has equivalent experience or knowledge.

B. The Bidder shall submit sufficient evidence that the manufacturers of the subcontracted major equipment have a minimum of 5 years current experience in successful manufacture of the generic type of equipment proposed.

C. The Bidder shall submit sufficient evidence that the equipment of the subcontracted manufacturers, by generic type, have been used successfully by the Bidder for rapid transit conversion substation systems for at least 5 years, or that this equipment is presently being used successfully in CTA substations.

D. Evidence submitted shall include a list of users name, telephone number and length of time in service.

E. The right is reserved to reject bids when, in the opinion of the Authority, insufficient evidence is submitted to establish the experience requirements of this specification.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.01 SUMMARY OF WORK

A. Traction Power Installation Summary Of Work

1. Traction power installation includes providing all labor, material, apparatus, equipment and services necessary to design, manufacture, test, deliver, install and commission new equipment at Washington substation as detailed in the Plans and summarized in the following:

   a. 800 volt dc switchgear assemblies
      1) Construct four (4) new DC feeder breaker cubicles with 4000A feeder breakers and add to the existing 800 volt DC switchgear lineup as shown on the drawings.
      2) Extend dielectric flooring below and around new DC switchgear as shown on the drawings.
      3) Install new control and SCADA cables/conduit from the new DC feeder cubicles to existing RTU. Add control relays in the RTU.

   b. DC Feeder and Getaway Switch
      1) Install (3) 1500 kcmil, 2000V cables from each new cubicle to a new get away switch on the Green Line near bent 2177. Cables shall be routed under the existing pink line and green line track structure, complete with cable supports and dead ends.
      2) Install two (2) new getaway platforms, and install four (4) new getaway switches (2 per platform).
      3) As part of the new cable installation, create a new 40’ section gap on the northbound track at STA 96+00.Install and connect cables from the new getaway switches 503, 504, 505, and 506 to the contact rail as per the contract drawings.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASURMENT

A. The work of GENERAL REQUIREMENTS FOR TRACTION POWER EQUIPMENT will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the work of GENERAL REQUIREMENTS FOR TRACTION POWER EQUIPMENT must be included in the contract lump sum price as shown in the Schedule of Prices for Traction Power Work.

4.03 PAY ITEM ACCOUNT NUMBER

A. Traction Power Work: 340000

APPENDIX A
DESIGN CONFERENCE AGENDA

APPENDIX A
DESIGN CONFERENCE AGENDA

A. FACTORY TOUR

1. Observe fabrication of existing orders.

2. Observe engineering capabilities.

B. GENERAL REQUIREMENTS

1. Review project job schedule so everyone understands the need for specified schedules of engineering, drawings, manufacturing, delivery, installation, test, checkout, and startup.

2. Establish and identify the following:

   a. Overall Project Manager
   b. Project Coordinator

   d. Contracts Engineer
   e Substation Design Engineer
   f. DC Switchgear Engineer

3. Set up procedure for design communications and chain of responsibility for:

   a. Chicago Transit Authority
   b. Equipment Supplier
   c. Contractor
   d. Review time for communication response
   e. Internet Web based project management system. (e-Builder)

4. Review procedure for issuance and approval of Shop Drawings including, but not limited to:

   a. Number, size and type of drawings. Title blocks.
   b. Approval time and schedule
   c. Compliance approval and release for manufacturer.
   d. Identification and marking of drawings
   e. Shop Drawing Schedule related to construction and installation schedules

5. Discuss possible methods of shipment, protection, schedule of shipment, breakdown of equipment with shipping splits, and coordination of equipment delivery to installation contractor.

6. Discuss each type of equipment being furnished and design data and calculations required by Specifications. Discuss installation Hold Points.

7. Discuss basic design data needed to proceed with installation specifications and drawings for substation buildings and services.

8. Discuss questions and specification relative to mode of operation, maintenance, support equipment, availability of support equipment, operations and maintenance manuals and data.

9. Review procedure and preliminary data for factory tests, in-line tests on equipment to insure a common basis for comparison of rectifier characteristics.

    1. Establish location, sequencing and timing for these tests.

        a. DC switchgear
        b. Require approved test procedure and final drawings 3 weeks (min) prior to testing

10. Review test result reports with essential calculations and data required.

11. Review procedure for approval and acceptance of factory, in-line, and other tests.

12. Review procedure and schedule for field testing, checkout and startup.

13. Requirements of manually operated control devices.

14. Indicating lamps shall be as specified.

15. Confirm addendums received, if any.

16. Schematic and wiring diagrams shall be as per CTA format.

17. Fuses for control circuits shall be 600 volts minimum for 125 VDC and below and 1000 VDC for all other circuits and shall have a minimum current interrupting capability of 20,000 amperes at 1000 VDC, with an L/R ratio of 0.05 seconds.

18. Submit data as to proposed control relays and devices for rectifiers, AC and DC switchgear, etc.

19. Bolted copper bus connections shall be silver plated. Bolted aluminum to aluminum connections shall be nickel plated.

20. All wire and cable shall be copper and in accordance with the Chicago Electric Code.

21. All indicating instruments shall be semi-flush mounted, taut band suspension, etc. or as approved in writing by the CTA.

22. Device identification as specified.

23. Discuss Checklists

C. DETAILED LIST OF DISCUSSION POINTS:

1. DC Switchgear

a. Certified base dimensions, mounting details, clearance dimensions, and weights.
b. Location and dimensions of power cable entrance, coordinate with drawings.
c. Location and dimensions of control entrance, coordinate with drawings.
d. Location for and type of relays used in feeder breaker reclosing and ground detection schemes.
e. Discuss feeder section control circuits.
f. Locations for and size of load measuring resistors and discuss load measuring scheme.
g. Test cabinet shall be integral with auxiliary cubicle.
h. Shipping sections split.
i. Details of isolation insulation between units switchgear anchoring method.
j. Standard control schematics.
k. Details for auxiliary compartment and umbilical cord operation.
l. Discuss switchgear wire.
m. Confirm that contractor will supply redundant over-current trips for feeder breakers and redundant reverse current trips for rectifier breakers.
n. DC feeder cables to be 1500 KCMIL stranded cable with EPR insulation. Cable supports shall be provided, so that cables are supported when disconnected.
o. All control circuits to be D.C. No inverter (D.C. to A.C.) is allowed.
p. Certification of all ratings required for D.C. breakers.
q. Short circuit study
r. Cable isolating links
s. Connecting the new switchgear with the existing switchgear, and existing RTU.

2. Interconnections

a. Wire identification, include cable number, destination location and terminal number, wire identifier and originating terminal block number.
b. Discuss Hold Points

D. OPEN DISCUSSION

1. Identify potential conflicts between contract requirements and equipment supplied
2. Identify potential risks during factory and field testing and contingency plans
3. Open discussion

END OF SECTION

SECTION 34 21 05

TRACTION POWER 800 VOLT DC SWITCHGEAR

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 DESCRIPTION

A. This section covers the requirements for designing, manufacturing, testing, delivering and commissioning indoor metal clad draw-out type 800 volt dc switchgear for 600 volt dc supply at the Authority's traction power substations.

B. The switchgear will be supplied directly from the rectifiers and will serve as the dc traction power supply to the traction feeders.

1.03 RELATED SECTIONS

A. Section 34 21 01, General Requirements for Traction Power Equipment.

B. Section 34 21 04, Traction Power 600 Volt DC Silicon Rectifier.

C. Section 34 21 09, Traction Power Support.

D. Section 34 21 10, Traction Power Equipment Installation.

E. Section 34 21 11, Traction Power Equipment Testing

1.04 SUBMITTALS

A. Furnish submittals in accordance with Division One Section, Submittals and Section 34 21 01, General Requirements for Traction Power Equipment.

1.05 QUALITY ASSURANCE

A. Contractor is solely responsible for the quality control of the work and shall comply with the requirements in Division One sections as well as all the regulatory requirements.

1.06 DELIVERY, STORAGE AND HANDLING

A. Deliver and store materials in manufacturer's original packaging. Store materials in climate controlled and protected dry locations off ground in accordance with manufacturer's instructions. Follow handling procedures approved by the manufacturer.

PART 2 - PRODUCTS

2.01 TECHNICAL REQUIREMENTS

A. The circuit breakers shall be 800 volt dc, single pole, air break, draw out type without negative disconnecting device and shall be of semi high or high speed classification suitable for operation on a system load bus supplied directly from up to four (4), 600 volt dc rectifiers operated in parallel. The circuit breaker in each rectifier circuit shall either be capable of withstanding a fault on the 600 volt dc bus until ac relays switch off the rectifiers, ac switchgear, or tripping a device which will protect the circuit breaker from damage under bus fault conditions. The operating mechanism shall be suitable for operation from the 130V volt dc supply and shall be electrically and mechanically trip free. The register type operations counter shall be mounted on the removable element.

B. The breaker tripping devices shall be furnished as required to provide reliable coordinated protection for the system. They shall have operating characteristic and adjustable ranges such as to trip for faults as outlined in Section 34 21 01, General Requirements for Traction Power Equipment. Range of trip settings shall be as specified in detail Specifications and calibration scales shall be calibrated covering full range of adjustable setting.

1. Circuit breakers shall be provided with an under voltage trip device which is magnetically held by flux produced by control power current which mechanically trips the circuit breaker upon reduction of control power voltage to 70 volt dc.
2. The mechanically latched dc circuit breakers which require control power for any part of an instantaneous over current or reverse current trip arrangement shall be provided with a second over current (reverse current) trip arrangement. The redundant instantaneous over current (reverse current) trip arrangements shall independently sense magnitude of circuit breaker current and may each utilize control power for their tripping arrangement but they shall have their own separate electrical component and they shall not share any common electrical components with the first overcurrent and reverse current arrangement. One of the two tripping arrangements may utilize the under voltage trip device to effect circuit breaker tripping. The discriminating trip equipment will not be acceptable as the second tripping arrangement specified above. However, the discriminating trip equipment may utilize a current sensor and trip coil in common with either of the required redundant instantaneous over current (reverse current) trip arrangements and may utilize the under voltage trip device to effect circuit breaker tripping. The discriminating trip device will have a separate counter. Each of the redundant instantaneous over current (reverse current) trip arrangement shall provide the overall

coordination as outlined in Section 34 21 01, General Requirements for Traction Power Equipment.

a. If a high speed trip box is furnished with the breaker, the coil and sensor monitoring circuits shall be furnished with the high speed trip box. High speed trip devices shall not utilize high voltage capacitors to store energy. These circuits must be approved by the Authority.
b. For the dc feeder circuit breakers the required second over current tripping arrangement shall be a solid state trip device, a current magnitude sensing non polarized relay which shunt trips or under voltage trips the circuit breaker, or other arrangement in conformance to these Specifications which is approved by the Authority.
    1) Tripping for the redundant over current arrangement shall be adjustable in the range of 8,000 amps to 24,000 amps of primary current. Long time delay over current tripping arrangement shall also be provided for dc feeder breakers, adjustable between 50 percent and 100 percent of feeder breaker rating and time delay adjustable range up to 3 minutes.
    2) Time vs. Amps curves shall be supplied.

c. Unless it can be established that the reverse current trip is fail safe for the rectifier dc circuit breakers, the second reverse current tripping arrangement is required) which may be a polarized solid state device, a current sensing polarized relay which would shunt trip or under voltage trip the rectifier circuit breaker, or provide other arrangement in conformance to these Specifications which is to be approved by the Authority.

3. The circuit breakers which are magnetically latched shall be latched by flux produced from control power and tripped by interaction between this flux and flux produced by circuit breaker primary current.

a. For the feeder dc circuit breakers, the magnitude of latch flux shall be such that at least 30,000 amperes of primary current are required to cause tripping shift of flux. The circuit breaker tripping arrangement shall not be responsive to rate of rise of primary current. The control power current for the magnetic latch shall not exceed 500 milliamperes. The dc feeder circuit breakers shall be provided with a second tripping arrangement which is easily adjustable to cause tripping between the limits of 8,000 and 24,000 amperes of primary current. This second tripping arrangement shall be a solid state trip device which electrically trips the circuit breaker, a current magnitude sensing non polarized relay which shunt trips the circuit breaker, or other arrangement in conformance to these Specifications which is approved by the CTA. The rate of rise discrimination equipment will not be acceptable as the second tripping arrangement specified above but may utilize a common trip coil. Long time delay overload trip devices shall be adjustable between 50 and 100 percent of breaker rating and must have time delay adjustable range up to 3 minutes.
b. For the rectifier dc circuit breaker, the magnitude of latch flux shall be at least 200 percent of the minimum value required for successful closing of

the circuit breaker without primary current. The circuit breaker tripping arrangement may be responsive to rate of rise of reverse current by use of inductive shunts or other means. The control power current for the magnetic latch shall not exceed 500 milliamperes.

C. The dc circuit breakers shall have peak current, momentary current, short time current and short circuit current ratings per IEEE Standard C37.14, required for operation in a substation with the number of rectifiers, of the size and type herein specified in operation. The specified short circuits are those applied to the load terminals of dc feeder circuit breaker and to the load terminals of the rectifiers.

1. The preferred ratings and test circuit values for high speed and semi-high speed shall be Table 10 of IEEE Standard C37.16. The dc circuit breakers which limit peak value of short circuit current shall have short circuit current rating equal to or greater than the maximum available prospective peak short circuit current and maximum available rate of rise of short circuit current under the short circuit conditions specified. The short circuit rating of the circuit breaker with delayed tripping shall not be less than 100,000 amperes.
2. The dc circuit breakers which do not limit peak value of short circuit current shall have short circuit current rating equal to or greater than the maximum available short circuit current during short circuit interruption under the short circuit conditions specified.
3. The dc rectifier circuit breakers shall have momentary current rating which is equal to or greater than the maximum available peak circuit breaker current with a short circuit at the load terminals of the circuit breaker.
4. The dc rectifier circuit breakers shall have short time current ability which is equal to or greater than the maximum RMS value of available circuit breaker current during a period of 250 milliseconds following application of short circuit to the load terminals of the circuit breaker. The short time current ability is defined as the designated limit of available RMS current which the circuit breaker can carry for a period of 250 milliseconds, without impairing the circuit breaker's ability to carry rated current without thermal runaway.
5. The dc feeder circuit breakers which do not limit the offset peak of short circuit current with fastest acting tripping arrangement provided shall have momentary current rating no less than the maximum peak value of maximum available short circuit current. The momentary current rating is defined as the peak value of current which the closed circuit breaker can withstand without impairing the circuit breaker's ability to meet its continuous current rating.
6. The dc feeder circuit breakers which limit peak value of short circuit current with fastest acting tripping arrangement provided shall have a momentary current rating no less than 120,000 amperes.
7. All dc circuit breakers shall be rated to successfully dissipate the maximum value of energy stored in system inductance during circuit breaker arcing under the short circuit conditions up to 2.5 miles distant and greater than 60msec. circuit time constant.

D. The circuit breaker close and trip circuit leads shall be wired through a plug in type disconnect device mounted on the removable element arranged to isolate normal local and remote control, including the dc source, from the breaker mechanism and permit local breaker operation from a plug in type control station while in connected position and when removed from the cubicle. Breaker shall be arranged to trip

automatically upon operation of any of its normal protective devices while under control of the plug in type control station when the breaker is in the connected position in the cubicle. The plug in control station shall be separately fused from the dc control bus.

E. The normal control equipment and circuits, whether mounted on the compartment door or other portion of the stationary unit structure, must be physically accessible and so connected as to permit testing and/or maintenance of relays and control circuitry in de energized condition while the circuit breaker is in it connected position and under the control of the plug in type control station. The wiring to the umbilical cord receptacle on the breaker and door of the auxiliary cubicle shall be individually insulated, using insulating sleeves at pins to prevent shorts.

F. All combination fuse disconnects shall be fully enclosed and mounted in the rear cubicles. The fuses shall be installed in enclosed fuse blocks and shall be draw-out or removable type.

G. Padlockable hinged doors shall be provided at front and rear of each circuit breaker unit suitable for mounting relays, meters, instruments and control devices. Doors shall be formed of sheet steel and shall be properly reinforced against distortions by suitable flanges and stiffening members. Hinges shall be heavy duty of a type approved by the Engineer. Full height doors shall be securely fastened in the closed position with a minimum of three latches and easily opened without the use of tools. For doors less than the full height of the equipment, a minimum of two latches will be acceptable. Doors shall be provided with stop positions, 90 degrees and 110 degrees to hold them securely in the open position. Door stoops shall be reachable without using a ladder. With the front door of any compartment in the 90 degree open position it shall not prevent the adjacent compartment door from being opened and its breaker completely removed from its housing.

H. Each circuit breaker shall be provided with a manual mechanical trip.

I. Current shunts, impulse transformers, transducers and other such equipment shall be accessible for testing and maintenance with the bus energized. All transducers shall be separately fused, and mounted in the rear of the cubicles.

J. All circuit breaker control circuits shall be arranged for both local and remote control and indication wired to suitable terminals for the top or the bottom connection to external control equipment.

K. Positive acting mechanical and electrical interlocking system shall be provided so that a breaker in the closed position cannot be disconnected from or connected to the bus. The switchgear shall have the capability of racking the breakers into the connected position with door closed. Breaker must be arranged so personnel are guarded from contact with energized parts while racking the circuit breaker into or out of the connect position. Structurally reliable automatic shutters shall be provided to prevent accidental personnel contact with current carrying parts when the removable element is in the test, disconnect, or completely withdrawn position. An engraved plastic laminated tag with white background and 1 inch high red lettering labeled "DANGER-DO NOT OPEN" as well as a warning sign as required by NFPA-70E shall be installed

on each shutter. The secondary disconnect, test and wiring within the cubicle shall be accessible from the front of the cubicle.

1. A centering device may be required for the racking handle, if the handle has difficulty in engaging the racking mechanism.
2. A motorized remote racking device shall be provided for each switchgear line up at each substation. The racking device shall be capable of remotely rack out any drawout dc breaker in the switchgear lineup. A 125 volt dc receptacle shall be provided in the dc switchgear auxiliary cubicle to supply power to the remote racking device.

L. Positive acting mechanical and electrical interlocking system shall be provided so that with a breaker in the connected position, the breaker cannot be closed with the door open and the door cannot be opened with the circuit breaker closed. Provision shall be made to lock out the breaker in the withdrawn position (When the breaker is racked out).

M. Bus shall be copper and shall be supported and braced to withstand short circuit stresses at least as great as those for which the breakers are designed. The contact surfaces of bolted joints in the bus and main connections shall be silver plated. The continuous ampere rating shall be as shown on the drawings.

N. The Contractor shall perform a short circuit study at each Substation to determine the maximum available short circuit current at the load side of the dc feeder breaker. The study shall be based on the requirements established in Section 2.01, Technical Requirements, of Specification 34 21 04, Traction Power 600 Volt DC Rectifier. If the short circuit current exceeds the dc feeder breaker rating, the Contractor shall determine and implement the method required to limit the short circuit current below the dc feeder breaker rating.

O. The floor area for installation of the dc switchgear shall extend 3 feet past switchgear and 6 feet in front of the switchgear and shall be prepared from plastic resin cement, Amazite or approved equal, 3/8 inch thick, to insulate switchgear structure from building structure. The switchgear shall be secured to the insulated epoxy floor with approved insulated anchors. The Contractor shall make provisions and supply suitable materials for insulation of the individual switchgear cubicles from each other.

P. The switchgear shall be arranged for top and bottom entries for power and control cables for all the cubicles of the dc switchgear lineup. Four solderless removable type terminal lugs (Penn Union type VVL, or approved equal) shall be provided for each feeder breaker and six (6) 1500 kcmil lugs for each rectifier breaker. Provisions shall be made to permit an individual quick disconnection and isolation of cables from load studs in stationary unit during emergencies by providing a removable bus bar between the stationary load stud and cable lug. This requires access to the connections through an easily opened hinged panel and sturdy support of the cable close to the connection point. The cable supports shall be provided so that all cables within each cubicle are self supporting. The copper bus properly supported and braced to withstand short circuit stresses shall be used for the rectifier positive output connection to the rectifier breaker.

Q. A separate 125VDC control circuit shall be provided from the existing DC distribution panel in the auxiliary compartment to each cubicle for control, tripping, metering and relay circuit for the breaker. The dc distribution panel breakers shall be similar to the ones described in Article 1.03E of Section 34 21 01, General Requirements for Traction Power Equipment.

R. Circuit breaker control circuit in each cubicle shall be separately fused from the dc sub distribution panel circuit. Fuse holders shall be ultra-safe type similar to Ferraz Shawmut fuse holder, where energized parts are not exposed until fuse is disconnected from the circuit. Fuses shall be rated 1000 volt dc. Switches rated 1000 volt dc shall also be provided to disconnect each breaker control circuit. In addition, each circuit breaker close circuit shall be protected by a secondary set of fuses to prevent opening of main fuses (and loss of trip ability) on close circuit faults. Fuse sizes shall be of appropriate current rating with 20,000 ampere dc (minimum) interrupting rating. All necessary fuses shall be furnished with the equipment.

S. A 48 volt dc bus, 2 wire, and emergency close bus, 1 wire, shall be provided integral with the assembly for connection to Devices 201D and supervisory contacts. The supply shall be factory-wired to suitable type terminal block in auxiliary compartment for bottom connection to purchaser's NO. 12 AWG conductors. Provide suitable screw-type terminal blocks for terminating control bus at each of the end cubicles.

T. All interconnecting cables between the cubicles carrying control voltage shall be installed in a closed and sealed cable trough in order to isolate a cubicle while it is being worked on, and still allow the power to pass through to the adjacent cubicles.

1.

U. The secondary and control wiring in each unit including that on removable element shall be ICEA Standard Type GRY SIS, No. 12 AWG or larger standard switchboard wire. For circuits 600 volt and above, use XLPO wire insulated for 2000 volt dc service, similar to BOSTRAIL AAR S-501 car wire, 2kV, extra flexible, XLPO insulation, soft annealed copper stranded conductor, as manufactured by DRAKA USA or approved equal.

V. Circuits requiring external connections shall be factory-wired to screw-type terminal blocks for connections to field wiring. Terminal blocks shall be General Electric Company, type EB-5, Marathon Series 1500 or approved equal. All wiring terminations to be Ring Style compression type, and shall be accessible from the front of the cubicle.

W. All metal work shall be thoroughly cleaned, treated against rust and corrosion, primed, bonderized and finished with 2 coats of ANSI 61 light gray color by powder coat painting process. The minimum dry film thickness shall be 1.5 mils. The manufacturer shall submit powder coating process plan for the Authority’s approval prior to painting the equipment. One (1) quart of matching touch-up paint shall be furnished for each assembly.

2.02 DETAIL EQUIPMENT

A. The equipment to be furnished shall be arranged as shown on the Contract Drawings and shall be in accordance with the following:

B. The auxiliary compartment shall be 30" wide and shall include but not limited to:

1.
2. One (1) panel mounted, momentary contact push button station with red and green indicating lamps for isolated close-trip operation of any circuit breaker in switchgear assembly through plug-in control cable, complete with auxiliary closing and tripping relays, as required, and plug-in control cable of suitable length to connect to plug-in type disconnect device on farthest breaker in planned ultimate installation, and with rack for cable storage.
3. Four (4), 2 pole, 30 ampere circuits, to provide control power for each new DC cubicle shall be furnished.

C. Each dc automatic re-closing feeder position shall be 24" wide and shall include, but not limited to:

1. One (1) metal enclosed stationary unit with 600 volt dc bus.
2. One (1) 4000 ampere air circuit breaker removable element with 12 stage auxiliary switch.
3. One (1) permissive control switch (REMOTE-LOCAL). REMOTE position at 12 o'clock, LOCAL position clockwise (Device 169).
4. One (1) 4000 ampere shunt with bi-directional indicating ammeter, 12,000-0-12,000 ampere scale and calibrated leads for all feeder cubicles.
5. One (1) removable element position switch with a minimum of 4 interchangeable stages.
6. One (1) control switch with red, green and amber indicating lamps (Close Right-Trip Left).
7. One (1) mechanical manual trip.
8. DC overcurrent relay, solid state, fixed mount, bi-directional, short, long, instantaneous, and rate of rise functions,50 MV input, Universal power supply 120 vac/125 vdc. Swartz type 76DC, Device 150.
9. One (1) solid state dc reclosing relay to provide logic and control for load measure and auto reclose of dc feeder breaker as follows:

    a. By monitoring and measuring the voltage and impedance on the feeder section, the relay determines whether to allow a manual close operation either locally or remotely via SCADA or initiate an automatic reclosing sequence after an automatic breaker opening. The voltage is measured with a volt transducer connected to the outgoing feeder.
    b. The high voltage setting of the relay shall be set for a threshold of 450 volts and above. In the tie condition, when the feeder is energized from the adjacent substation, the feeder should be near normal voltage (higher than 450 volts), then it is assumed the conditions are normal and the feeder breaker can be closed without initiating the load measuring cycle. In the tie condition, if the voltage is measured between 50 and 450 volts, the breaker reclosing is not permitted. The time out timer begins to count

and after five successive cycles, if the breaker fails to close, it will be locked out.

c. The low voltage setting of the relay shall be set at 50 volt. This setting assumes that the feeder is not energized from the adjacent substation and that the voltage rise in the negative bus is due to the negative return current in the running rails. In the stub condition, if the voltage sensed by the transducer is less than 50 volts, after initial time delay, a load measuring operation is initiated, which measures the resistance between positive feeder and the negative bus. A resistance which is below preset value indicates short circuit on the rails and reclosing is not permitted. If the measurement is greater than one ohm, the reclosing is allowed. (A load measure output pulse from the 182 relay cause 129 relay to close, which inserts load measuring resistor in series with the 600 volt dc bus and the feeder positive cables. This effectively places a reduced voltage on the feeder, which 182 relay can measure and convert to ohms).

d. The relay package shall be dc reclosing, low threshold, draw-out case, LED meter, bi-directional load measuring, voltage compensating, load measure memory, 24-125vdc input power, 40MA supply current at 125 volt dc, high 600 volt and low 200 volt,10 to 100 ohm resistor application, load ohm threshold (.15 ohm to .45 ohm), 1 to 5 close attempts, 1 to 3 cycles per close, Fault / Load measuring / Close / Lockout, outputs rated 2A / 500 volt dc, 0-800 volt, 0-10 ohm meter. The relay package Swartz type, Part NO C4280-564 and transducer Part NO. C4280-901, Device 182/183.

10. Measuring resistors shall be located on top of the feeder position stationary units and shall be provided with ventilated enclosures. The Contractor shall provide interconnecting wire and insulated resistor supports.
11. Disconnect switches for load measuring circuit (Device 108x) shall be rated for 800 volt dc.
12. One (1) dc voltage transducer, complete with calibrating resistors, suitable for isolation of metering potential and supervisory telemetering with rated input 150 volt to 5 kV dc. Calibrating resistors may be added, if required, and sized to produce 0-1 mA dc output for and minimum 10 volt burden (10k ohm) for 0 to 1000 volt dc input, Paladin 256 series and class 0.2 or approved equal. The transducer shall be fused separately with a Ferraz type fuse disconnect or equal.
13. One (1) bi-directional dc current transducer, suitable of insulation of metering current and supervisory telemetering. Primary leads shall be sized, installed and calibrated in factory, 1.0-0-1.0 milliampere into 10k ohm from 50 millivolt, 6,000 ampere shunt to produce output current ranged scale +/-16,000 ampere, 0.2% accuracy, Paladin 250 series, class 0.2 or approved equal. The transducer must be separately located as close as possible to the shunt, Device 150.
14. One (1) emergency close interposing relay (Device 201D) for remote closure of feeder breaker without load measuring.
15. One (1) master relay (Device 201X) operated both by local control and remotely by the Authority's supervisory control.
16. Terminal lugs for 3-1/c 1500 kcmil copper, 2 kV EPR insulated, traction power cable.
17. One (1) lightning arrester in a fiberglass enclosure with a viewing window, 750 volt dc nominal voltage, 1820 volt maximum continuous operating voltage,

metal oxide type, discharge capability of 2.6 kJ / kV at 500 amps or less. The enclosure shall be similar to UL listed JIC size raised cover enclosure manufactured by Allied Moulded Products Inc. The arrester with the enclosure to be shipped loose for field installation.

D. Miscellaneous Requirements:

1. The Contractor shall stock complete sets of all printed circuit cards and non-standard parts and components in a facility which can deliver such parts to the Authority within 72 hours of receiving an order or notification of a failure. Complete manufacturing information, i.e., artwork, bill of material, etc., shall be archived in the manufacturing facilities for at least ten (10) years. Any possible new design in the future, by this manufacturer shall be compatible within the system to be supplied to the Authority under this Contract. If the Contractor should decide to discontinue manufacturing of the load measuring/automatic re-closing system, complete manufacturing information shall be made available to the Authority.
2. In addition to the warranty required by these Specifications, the manufacturer shall provide the following one (1) year warranty for his system:

    a. For the purposes of this warranty, a failure shall be defined as, "The System not giving or being able to give a close command to the feeder breaker, when required, if the Traction system parameters correspond to the load measuring/re-closing system settings or the system giving a close command when the Traction system parameters do not correspond to those settings".

3. Each 4000 ampere air circuit breaker removable element shall be identical and interchangeable. One (1) spare 4000 ampere air circuit breaker removable element shall be supplied at each substation. The spare circuit breaker element shall not be incorporated into the dc switchgear lineup but shall be supplied loose.
4. Accessories for handling removable components in the switchgear assembly including breaker racking in crank, a remote racking device maintenance closing device, fork-lift type breaker handling dolly (or wheeled removable element), arc chute removing device, and/or other devices as required. All accessories shall be designed for reasonable handling of removable components by 1 person of average strength. A centering device may be required for the racking handle if the handle has difficulty in engaging the racking mechanism. Two (2) racking handles and two (2) maintenance closing devices shall be furnished for each of the three substations.
5. Auxiliary relays, fuses, resistors and all other devices required for a complete and operating system.

2.03 Quantity of Equipment Required

A. Each of the items listed below shall be furnished and delivered at the substation sites in quantity and type as listed hereinafter. Each type of equipment shall be equipped as detailed in Paragraph 1.03 of this section. Each switchgear line-up shall include assorted switchgear positions of various types listed below and shall be incorporated

into one continuous enclosure made up of compartments as required and shown on the Drawings:

1. At Washington Substation

    a. Item 1. Four (4) – 4,000 ampere automatic reclosing feeder breaker positions.
    b. Item 2. One (1) - Spare 4,000 ampere air circuit breaker removable element. The breaker element shall not be incorporated into the dc switchgear lineup but shall be furnished loose.
    c. Item 3. One (1) - Set of accessories including a remote racking device.

B. The Manufacturer must furnish certified evidence of prior tests that the proposed switchgear meets these specifications. In the absence of such test data, the Authority reserves the right to require a factory test demonstration of said equipment.

PART 3 - EXECUTION

3.01 INSTALLATION

A. See Section 34 21 10, Traction Power Equipment Installation for the dc switchgear installation requirements.

3.02 TESTING

A. See Section 34 21 11, Traction Power Equipment Testing, for the dc switchgear testing requirements.

3.03 SUPPORT EQUIPMENT

A. See Section 34 21 09, Traction Power Support, for the dc switchgear list of support equipment.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASURMENT

A. The work of TRACTION POWER 800 VOLT DC SWITCHGEAR will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the work of TRACTION POWER 800 VOLT DC SWITCHGEAR must be included in the contract lump sum price as shown in the Schedule of Prices for Traction Power Work.

4.03 PAY ITEM ACCOUNT NUMBER

A. Traction Power Work: 340000

END OF SECTION

SECTION 34 21 09

TRACTION POWER SUPPORT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This section covers the requirements for furnishing the support for the traction power equipment specified in Specification Sections 34 21 03, 34 21 04, 34 21 05, 34 21 06, 34 21 07 and 34 21 19.

B. The Contractor shall furnish a reasonable number of parts such as to insure adequate supply for installation and testing of the various components of equipment furnished and installed under this Contract for traction power Substation work. These parts shall include but not be limited to power fuses, control and instrument fuses and installation hardware such as bolts, nuts, and other special devices. Such parts shall be delivered at the time with the equipment to which it applies.

C. The Contractor shall furnish all necessary installation and maintenance tools such as wrenches, threading devices, etc., for all fittings which do not conform to U.S. Screw, Bolt and Pipe Standards.

D. Related Sections: The following sections contain requirements that relate to this section:

1.
2. Section 34 21 05, Traction Power 800 Volt DC Switchgear.

1.03 SUBMITTALS

A. Furnish submittals in accordance with Division One Section, Submittals and Section 34 21 01, General Requirements for Traction Power Equipment.

1.04 QUALITY ASSURANCE

A. Contractor is solely responsible for the quality control of the work and shall comply with the requirements in Division One sections as well as all the regulatory requirements.

1.05 DELIVERY, STORAGE AND HANDLING

A. Deliver and store materials in manufacturer's original packaging. Store materials in climate controlled and protected dry locations off ground in accordance with manufacturer's instructions. Follow handling procedures approved by the manufacturer.

PART 2 - PRODUCTS

2.01 Requirements

A. For each Substation, except where noted otherwise, the Contractor shall furnish at the time of delivery of equipment the following items to reduce down-time on the system due to unit failure: Any reference to the specific model or manufacturer shall be substituted with the type of device supplied under this Contract.

1.
2. Two (2) complete sets of main contacts, arcing contacts and arc chute assemblies. In case of vacuum breaker, three (3) sets of vacuum interrupters (bottles).
3. For DC breaker supplied, two (2) electromotive devices integral to the breaker used for closing and tripping two (2) control switches of each type two (2) solid state reclosing systems (if supplied), including but not limited to, closing coils, closing motors, spring charging motors, trip coils or holding coils, eight (8) load measuring resistors, two (2) electronic tripping devices and test set.
4. For each type of breaker supplied two (2) complete sets of main current carrying disconnect assemblies, two (2) complete sets of auxiliary control disconnect assemblies, and two (2) sets of auxiliary contacts.
5. Two (2) lightning arrestors of each type.
6. One (1) of each type of springs used in each type of breaker furnished.
7. One (1) of each type of relays in use with all traction power conversion equipment supplied..
8. For each type of fuses supplied for traction power equipment, furnish minimum of 10 percent but not less than four (4).
9. Two (2) load measuring relays and one (1) simulator for testing and troubleshooting purposes.
10. One (1) of each of the various types of transducers in use with all traction power conversion equipment included in this Specification.
11. Additional test sets and software to set, test and calibrate all electronic relays.
12. The Contractor shall also furnish at the time of delivery a detailed list of recommended support parts and/or devices for the Authority's review and

approval. The prices shall be furnished with this list along with names of suppliers and catalog numbers for such parts if they are not originally manufactured by this Contractor.

B. The Contractor shall provide training to up to 40 CTA personnel, in two sessions (20 personnel per session), in Chicago on operation, maintenance, and troubleshooting procedures of the DC Switchgear and breakers provided. Complete instruction manuals (including schematics and wiring diagrams showing all internal solid state components) shall be provided for all personnel at least one (1) week in advance of the course. The intent and general approach of the training shall be to provide the Authority's personnel with adequate classroom and practical training necessary to operate and maintain the Chicago Transit Authority Traction Power Substations.

PART 3 - EXECUTION (NOT APPLICABLE)

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASURMENT

A. The work of TRACTION POWER SUPPORT will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the work of TRACTION POWER SUPPORT must be included in the contract lump sum price as shown in the Schedule of Prices for Traction Power Work.

4.03 PAY ITEM ACCOUNT NUMBER

A. Traction Power Work: 340000

END OF SECTION

SECTION 34 21 10

TRACTION POWER EQUIPMENT INSTALLATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This section covers the requirements for installation of traction power equipment specified in these specifications and at the location shown on Contract Plans. Installation of 15kV ac power cables shall be in accordance with ComEd Engineering Department requirements. Installation of dc traction power cables shall be in accordance with Section 34 21 25, Traction Power Cables. Installation of dc traction power disconnect switches shall be in accordance with Section 34 21 40, Traction Power DC Disconnect (Knife) Switches and Section 34 21 41, Traction Power DC Disconnect (Knife) Switch Enclosures. Low voltage power and control wiring installation including installation of conduit and fittings, cable trays, junction, pull and terminal boxes and related materials shall be in accordance with Section 34 21 65, Basic Electrical Materials and Methods – Traction Power. The completed installation shall provide fully coordinated and fully operational electrical system.

B. The Contractor shall take every precaution in handling, setting, aligning and assembling the equipment to avoid distortion of frame. The Contractor shall thoroughly familiarize himself, with the manufacturer's instructions before attempting to handle, install and operate the equipment. Contractor shall insure that all personnel working with the equipment fully understands the operation of the various components to avoid misoperation, damage to equipment and possible personal injury.

C. The Contractor shall make all equipment assembly connections between shipping units, including all bolted connections to mechanically assemble the units and installation of all splice plates, connecting bases and throats.

D. The Contractor shall make all electrical connections between shipping units, including all bolted bus connections and connections of control and auxiliary circuits.

E. The Contractor shall make all electrical interconnections between all equipment installed. All wires shall be labelled with approved wire markers. Each wire in a multi conductor cable shall be identified with the cable number, destination location and

terminal block number, wire identifier and originating terminal block number. An interconnection diagram must be approved prior to commencing any work.

F. Routing and method of installations of 12.6 KV ac circuit cable and conduits and dc traction feeder positive and negative return cables are shown on Contract Plan.

G. Basic routing of conduits and cables for control and auxiliary circuits for interconnecting equipment and devices are shown on Contract Plans. However, Contractor shall determine the specific application of these cables to satisfy all control, indication, supervisory and auxiliary functions specified. Installation of cables shall be in accordance with the Authority's approved cable schedule and the Contract Drawings.

H. The Contractor shall make all ground connections to the equipment from the ground buses in the Substations, as shown on the Contract Plans.

I. Completed installations shall be tested and checked out in accordance with Section 34 21 11, Traction Power Equipment Testing, and as specified in other applicable sections of the Specification.

J. Related Sections: The following sections contain requirements that relate to this section:

1. Section 34 21 01, General Requirements for Traction Power Equipment.
2. Section 34 21 05, Traction Power 800 Volt DC Switchgear.

1.03 SUBMITTALS

A. Furnish submittals in accordance with Division One Section, Submittals and Section 34 21 01, General Requirements for Traction Power Equipment.

1.04 QUALITY ASSURANCE

A. Contractor is solely responsible for the quality control of the work and shall comply with the requirements in Division One sections as well as all the regulatory requirements.

1.05 DELIVERY, STORAGE AND HANDLING

A. Deliver and store materials in manufacturer’s original packaging. Store materials in climate controlled and protected dry locations off ground in accordance with manufacturer’s instructions. Follow handling procedures approved by the manufacturer.

PART 2 - PRODUCTS

2.01 DETAILED REQUIREMENTS

A. DC Switchgear

1. DC switchgear shall be fully assembled and completely installed in accordance with the Authority's approved manufacturer's drawings at location shown on Contract Plans. All dc switchgear units shall be insulated from each other by means of minimum of 1/4" thick insulated material.
2. Insulated anchors shall be furnished and installed in the floor slab in accordance with manufacturer's instructions. The floor area at the dc switchgear shall be covered with a layer of insulated materials to insulate the switchgear enclosure from building structure. Care shall be taken that the insulated floor area is not scraped or otherwise damaged during installation. After completion of the installation the dc switchgear structure shall be completely insulated from the building structure.
3. The switchgear units shall be assembled in such a manner as to ensure proper leveling, proper alignment between the various shipping groups and for proper placement of all the conduits that are required for equipment interconnection. The Contractor shall make all necessary electrical connections between the units of the assembly, including the joints in the 800 volt positive bus.
4. One lightning arrester for each outgoing feeder cable shall be mounted horizontally in a fiberglass enclosure with a viewing window, under the dc switchgear floor. The enclosures shall be similar to UL listed JIC size raised cover enclosure manufactured by Allied Moulded Products Inc. The arresters shall be connected to load terminal of each outgoing feeder.
5. The breaker test cabinet shall be installed at the location shown on Contract Drawings or as directed by the Authority. A clear space of 1/4 inch, minimum, shall be provided between the back of the cabinet and the wall. Steel channels or straps, or equal, of suitable thickness shall be fastened to the masonry and tapped and drilled for mounting of the test cabinet using galvanized machine bolts.
6. After completion of the installation, the Contractor shall ensure that all doors operate freely and the breaker removable elements can be moved into and removed from the housings without encountering the change of elevation from within the housing to the floor. Contractor shall correct all misalignments to the satisfaction of the Authority.

PART 3 - EXECUTION (NOT APPLICABLE)

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASURMENT

A. The work of TRACTION POWER EQUIPMENT INSTALLATION will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the work of TRACTION POWER EQUIPMENT INSTALLATION must be included in the contract lump sum price as shown in the Schedule of Prices for Traction Power Work.

4.03 PAY ITEM ACCOUNT NUMBER

A. Traction Power Work: 340000

END OF SECTION

SECTION 34 21 11

TRACTION POWER EQUIPMENT TESTING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This section covers the requirements for factory and field testing of the traction power equipment described in these specification sections.

B. All traction power equipment furnished and installed under this contract shall be subject to the test program described herein. Testing shall include tests at a manufacturer's facility and in the field. Contractor shall submit all factory and field test plans for approval prior to test being performed. A sample Field Test Plan is included as Appendix F as part of this specification.

C. The Contractor shall formulate overall test program of the equipment which shall include but not be limited to the tests specified in this Section to ensure equipment compliance with the relevant standards, this Specification and satisfactory and reliable performance in intended operation.

1.03 FACTORY TESTS

A. Tests at the factory shall include but not be limited to:

1. Manufacturer's standard tests.
2. Tests as per currently applicable NEMA, IEEE, and ANSI Standards.
3. Any other test to ensure satisfactory performance of the traction power equipment.

1.04 Field TEST

A. Tests in the field shall include but not be limited to:

1. Manufacturer's standard tests
2. Test as per currently applicable NEMA, IEEE and ANSI Standards.

3. Any other tests to ensure satisfactory performance of the traction power equipment.

1.05 TEST REPORTS

A. The Contractor shall submit certified copies of test reports for all the tests conducted at the factory and in field for the Authority's approval. Test reports shall be submitted to the Authority within seven days after completion of tests. Test reports shall contain the characteristics curves, etc. where required for interpretation of results.

1.06 CONDITIONS FOR TESTS

A. General Conditions

1. Prior to testing of any equipment specified in this Section, all of the following conditions shall be fulfilled by the Contractor:

a. All shop drawings of the equipment to be tested have been approved by the Authority.
b. The Contractor shall submit a step by step test procedure including pass-fail criteria to the Authority four weeks in advance of the commencement of the test. The Authority reserves the right to add, delete and make necessary changes in the test procedure. The Contractor shall arrange to conduct all tests per the Authority’s approved procedure.
c. A minimum of four weeks advance notification shall be given to the Authority on the scheduled date of tests to enable them to witness the same.
d. Testing shall not commence without an approved test procedure.
e. Relay coordination study and all solid state relay programming files shall be submitted and approved prior to any ac switchgear testing.

B. Witnessing Tests

1. The Authority’s personnel and/or their authorized agents will witness complete testing of all equipment unless a waiver is granted, in which case test reports of equipment for which waiver was granted, shall be submitted for review to obtain clearance for packing and shipping. Waiver of witnessing tests on equipment shall not be construed as a waiver for all remaining equipment either of the same type or different type.

C. Responsibility

1. The Contractor shall assume full responsibility during the factory and field testing of all equipment and installation provided by him. Should there be any loss or damage to such equipment, materials or the building as result of these tests, the Contractor shall be fully responsible for replacing the damaged equipment and repairing the building. Replacement of damaged

equipment shall include all costs, including but not limited to, transportation of, testing and installation of replacement equipment.

D. Rejection and Retesting

1. Failure of equipment to successfully pass the tests or to meet ratings shall be sufficient grounds for rejection of equipment.
2. Any equipment rejected shall be retested in presence of the Authority after rectification. If the modifications or changes are such as to affect any of the drawings, diagrams or any other documents submitted and accepted by the Authority, revised drawings or diagrams shall be submitted, showing proposed changes and Authority's approval obtained before changes or modifications are made on the equipment. Modifications or changes which do not warrant revision of any drawing shall be furnished to the Authority along with notice of retesting.
3. If it is not possible to rectify rejected equipment, new equipment shall be manufactured and the requirements of the drawings and design calculations of the original unit shall be applicable for the new unit.

E. Cost of Rectification or New Unit

1. The entire cost of rectification or new unit shall be borne by the Contractor including retesting and cost of witnessing retesting

PART 2 - DETAIL REQUIREMENTS FOR FACTORY TESTS

2.01 FACTORY TEST

A. General

1. If facilities for conducting any of the tests listed below are not available to the Contractor, these tests shall be conducted elsewhere by him or by an independent agency as approved by the Authority. Contractor shall, however, clearly indicate in his proposal, the name of the facilities where he intends to conduct those tests.

B. DC Switchgear

1. Following test listed in ANSI C37.14 as "Design Tests" shall be conducted on one representative dc circuit breaker of each rating:

a. Dielectric withstand test
b. Continuous current test
c. Short-circuit current interrupting test: The short-circuit test value shall be as calculated for the Substation with the equivalent of four (4) 2500 kW rectifiers feeding the dc bus. Primary ac system available fault capacity shall be taken as 500 MVA at 12.6 kV and X/R Ratio 15. The fault shall be between the load side terminals of the feeder breaker and the negative bus of the substation. The dc power source shall preferable be from silicon rectifiers. Engineer's approval shall

be obtained prior to testing if other sources of supply are to be used. Previous test certifications are not acceptable.

d. Endurance test
   1) Electrical endurance test
   2) Mechanical endurance test

2. Following tests listed in ANSI C37.14 as "Production Tests" shall be conducted at the manufacturer's facility on each and every dc circuit breaker.

   a. Calibration tests on the individual direct acting trip device prior to final assembly
   b. Control and secondary wiring check test
   c. Dielectric withstand test
   d. Mechanical operation test
   e. Calibration test
      1) Direct acting trip devices
      2) Undervoltage trip device

   f. Manufacturer's standard tests not included in the above tests.

3. Following tests listed in ANSI C37.20 as "Design Tests" shall be conducted on one representative dc switchgear assembly.

   a. Dielectric tests
   b. Rate continuous current tests
   c. Momentary current tests
   d. Mechanical operation tests
   e. Sequence tests
   f. Flame-retardant tests

4. Following tests listed in ANSI C37.20 as "Production Tests" shall be conducted at the manufacturer's facility on each and every dc switchgear assembly.

   a. Dielectric tests
   b. Mechanical operation tests
   c. Electrical operation and control wiring tests
      1) Control wiring insulation tests
      2) Polarity tests
      3) Sequence tests

PART 3 - DETAIL REQUIREMENTS FOR FIELD TESTS

3.01 FIELD TEST

A. General

1. Contractor shall perform the following field tests on all equipment specified in this Section after installation of the equipment, and all 15kV cable installation

is complete. Field tests are to be performed to supplement the factory tests and to ensure proper operation of equipment and proper calibration and coordination of protective devices. Contractor shall furnish and set up all special equipment required for the tests, including relay tests set, switches, properly calibrated indicating instruments, timing devices, shorting devices, loading devices and other associated appurtenances as may be required. The Contractor shall provide assistance with the commissioning and testing of batteries and charger. IMPORTANT NOTE: All short circuit tests shall be recorded on the state of the art recorder such as "Astromed Dash 8", or approved equal. Light sensitive recording media such as "Oscillograph" paper will not be accepted.

2. The work includes furnishing labor, material, test instruments and services necessary to perform required testing and checking of electrical equipment installation.
3. All tests shall be successfully completed to show that the installation meets the specification requirements and that the equipment and devices operate as intended, before final acceptance by the Authority.
4. Tests and checkouts shall be conducted in accordance with the Engineer's approved test procedure specified herein and in National Electrical Code, and applicable Standards and Specifications' of ANSI, NEMA, etc.
5. Contractor shall provide properly qualified personnel who shall be responsible for supervising, coordinating, and performing all the electrical field testing and checking work and who shall maintain a written record of tests conducted.
6. Testing and checkouts shall be performed in the presence of the Engineer.
7. Contractor shall furnish four copies of all tests results to the Engineer. Result sheets shall include date of test, personnel involved, items tested, type of tests and test data.
8. Any equipment or material damaged due to improper test procedure or test apparatus handling shall be replaced or restored to original condition by Contractor at his expense.
9. Safety devices including but not limited to rubber gloves and blankets, screens and barriers, danger signs, padlocks, etc., shall be used to protect and warn all personnel in the vicinity of the tests.
10. All test instruments used shall have a certified calibration sticker showing last date of calibration and expiration date.
11. Contractor shall test ComEd 15 kV metering PT’s and CT’s as per ComEd requirements.
12. Review CT performance curve to verify that CT’s will not saturate under short circuit conditions.

B. Field Test Requirements

1. Contractor shall formulate a complete Field Test procedure for all equipment to be furnished and installed under this Contract. Test procedure shall be comprehensive and shall include the required tests as specified in relevant standards of ANSI, NEMA and IEEE, supplementing the Factory Test Procedure.
2. The Contractor shall submit the test procedure to the Engineer for review and approval well in advance to the commencement of field tests. Engineer reserves the right to add, delete or make necessary changes in the test

procedure. The Contractor shall arrange to conduct all the field tests as per the Engineer's approved procedure. Since the Contractor is responsible for the performance and installation of the equipment furnished under this Section, he shall, therefore, prior to testing, verify that the installation is proper and in accordance with all applicable installation instructions specified herein.

C. The following field test shall be performed:

1. Prior to commencement of equipment testing, verify that all equipment interconnections have been installed using the latest approved revision of all equipment drawings. Perform test to prove the correctness of all control, protection and indication circuits in the, dc switchgear, , and SCADA.
2. Every dc circuit breaker supplied shall be thoroughly inspected and certified by the Contractor's Engineer.
3. Check relay and trip devices settings and coordination.
4. Perform dielectric, functional and operations tests of all equipment and of all devices and circuits.
5. Calibration test shall be performed on all equipment supplied in this contract:

    a. Item 1 - All 600V dc auxiliary compartments
    b. Item 3 - All 600V dc automatic reclosing feeder breaker positions
    c. Item 4 - All Spare 600V dc air circuit breaker removable element.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASURMENT

A. The work of TRACTION POWER EQUIPMENT TESTING will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the work of TRACTION POWER EQUIPMENT TESTING must be included in the contract lump sum price as shown in the Schedule of Prices for Traction Power Work.

4.03 PAY ITEM ACCOUNT NUMBER

A. Traction Power Work: 340000

APPENDIX A

SAMPLE FIELD TEST PLAN

APPENDIX A

SAMPLE FIELD TEST PLAN

The Field Test Plan includes tests which shall be performed by the Traction Power Equipment Supplier and/or his Sub-supplier. These tests are in addition to the test specified elsewhere in the Traction Power Substation Specification Sections. This test plan is to be used as a guide and is not all inclusive. Contractor shall submit a formal field Test Plan for approval prior to performing any field tests.

SAMPLE FIELD TEST PLAN

Table of Contents

Substation Equipment

GENERAL ----------

PHASE I Mechanical and Electrical Inspections and Test Prior to Control Check

PHASE II Control Function and System Interconnection Checks

PHASE III Main Power Energization

Pass/Fall Criteria

The pass fail criteria for these tests are contained in the specification itself.

Specifically:

- Equipment is deemed to have passed "Hi-Pot" Test if the voltage can be reached and sustained for one minute breakdown.
- On all other tests the equipment is to function in the intended manner as shown on the drawings, in instruction books, and in the specification.

PHASE I – TEST EQUIPMENT

Special Devices

Megger Tester: Simpson or equal
0-1,000 mega ohm 1000 V dc

HIPOT Device: Hipotronics
Model PL880 or equal

Standard Device:

Yellow-black rope or ribbon
High voltage signs
Ground cable
Terminal – block shorting jumper

Variable transformer input 115V 10A
Single phase bridge 15A 250V dc
Capacitor 350V dc, discharge resistor

Tool Kit
Low resistance OHMETER (Ductor)
(Capable of supplying 100A current output)

PHASE IA – DC SWITCHGEAR

These tests may be done independently from other aspects of Phase 1. Tests to be conducted by traction power equipment supplier.

1) DC Breaker Racking Mechanism Function

   - Withdraw dc breaker from cubicle
   - Check for interchangeability of like function
   - Check for incorrect dc breaker size and place

2) DC Breaker Mechanism Function. Operate for manual spring charging, close/open, slow closing.

3) DC Breaker Megger Test: Main Contracts

   - Megger open and closed position

   Control wiring with spring charging motor

   - Motor connected, megger 1000V dc for 1 minute

4) DC cubicle (Line Up) Busbar Megger to Skin

   DC BREAKER WITHDRAWN OR IN DISCONNECT POSITION. Interconnect positive busbar with negative reference bus.

   Open isolator fuses. (Make sure transducers and ground detectors are isolated).

   - Megger busbar 1000V dc for I minute.

5) DC Cubicle Control Wiring Megger to Skin

   - Megger control wires 1000V dc for 1 minute

6) Check Breaker Contract Resistance

PHASE II – CONTROL FUNCTION AND SYSTEM INTERCONNECTION CHECKS

Testing in this Phase should begin with control power (Phase II, Battery, Charger, and Inverter) and then in general follow the power train sequence. See details for exact limiting conditions. Control functions, connections, and interconnections must be checked through and circuit paths yellow lined in on elementary diagram.

Special Devices

Relay Tester: EIL Instrument or Equal, Model RTS 100D

Standard Devices

Tool Kit

Multimeter

120V variac 10A

Single phase rectifier bridge 15A 250V dc

Variable power resistor 0-1 ohm 25amps

450V ac, 3 phase bridge rectifier

Oscilloscope

Ramp generator to test 150 devices

PHASE IIA – DC SWITCHGEAR

DC switchgear may be tested independently from other systems, provided all interfaces with other systems are properly lined in and confirmed. Battery set must be operative. Tests should be made through the annunciator board and dc switchgear tripping circuits. All elementary diagrams must be lined in completely. If complete system verification cannot be made at once, check out portion of the system and line in.

Record all readings on elementary diagrams.

Following tests to be performed by equipment supplier:

1) Protection confirmed by observation and operation.

   a. Tripping devices shall be given mechanical inspection.
   b. Check polarity of trip sensors and sensitivity of direct acting reverse current trip.
   c. Trip circuits (short time, rate of rise, reverse current, instant) tests with function push button and removal of control power to confirm tripping on loss of control power.
   d. Visually verify relay setting (direct acting, semi-high speed, rate of rise).
   e. All protective relays shall be tested for accuracy, proper operation, and function (devices 150, 176, 32 and transducers).

2) Demonstrate operation of structure ground relay (164) and cubicle isolation.

   a. Record pickup, dropout voltage and circulating current for all ground (164X) and hot structure (164C) detectors.
   b. Demonstrate operation of structure ground relay (164) while control power being supplied from alternate power source (if any).

3) Check for operation of dc breaker electrical close and trip function.

4) Check for umbilical cord operation of all dc breakers for electrical close and trip functions.

5) Check for mechanical operations (rack in and out and interlocks) of dc breakers.

6) Check for kirk key interlock (cathode breaker and disconnect switch), if applicable.

7) Check for interchangeability of breaker and non-interchangeability of breakers with unlike rating.

8) Check for proper operation of station alarms and associated annunciators. Record pickup and dropout values where required.

9) The dc reclosing circuit shall be thoroughly tested and calibrated by simulating inputs on the station bus and third rail with power bridge and load resistor. Make initial setting on reclosing module. Setting values shall be recorded.

PHASE IIB – ANNUNCIATORS AND METERING

Annunciators and metering must be tested as an integral part of balance of Phase II.

Following tests to be performed by traction power equipment supplier.

1) Annunciator

Check functions of annunciators with the main system. Observe all indication lights, horns, pushbutton functions, and test switches. Line in elementary diagram.

PHASE III – MAIN POWER ENERGIZATION

- All power cables and control interconnections complete
- All previous tests and equipment inspections verified

Initial energization to be by traction power equipment supplier

Standard Equipment

Tool Kit

Multi-meter

Clamp on ammeter

PHASE IIIA – SUBSTATION ENERGIZATION

Following tests to be performed by traction power equipment supplier.

1) Review previous test data.

2) Visually check all power connections.

   a. DC feeder connections

3) Visually check protective relay settings.

   a. DC switchgear (including recloser)

4) Rack dc breakers to disconnect position. Put breaker controls in local. Check the switchgear and access panels for tightness. Close and latch all cubicle doors.

PHASE IIIB – DC FEEDER ENERGIZATION (SUBSTATION)

1) Open rectifier ac feeder breakers. Put breaker control in local. Rack in all dc breakers.

2) Confirm recloser operation by giving close command through control switch and observe recloser lock out on dead bus.

3) Close rectifier ac feeder breakers

4) Energize feeder with close command from control switch.

TEST REPORT

TEST REPORT (continued)

PHASE IA **DC Switchgear**

SUBSTATION:

SERIAL NO: TESTED BY:

DATE OF TEST: VERFIED BY:

1. MECHANICALLY/VISUALLY/INTERCHANGEABILITY

   Breaker draw out slides
   Shutters

ITEMS/REMARK	VALUE	STATUS
2. Megger switchgear post bus Bar with reference bus bar to Skin connected to ground	MOhm @1000V dc	
Remarks: Pos. bus bar and ref. Bus shorted, load measuring Fuses open		
a. Megger post bus outgoing bars	MOhm @1000V dc	
Remarks: 100V dc		
3. Megger switchgear control wiring To skin connected to ground.		
Remarks: All control wiring Interconnected at the terminals.		

TEST REPORT (continued)

SUBSTATION:
SERIAL NO: TESTED BY:
DATE OF TEST:: VERFIED BY:

a. Megger switchgear to ground MOhm @1000V dc

Remarks:

b. Megger ground relay panel to Ground MOhm @100V dc

TEST ITEMS NO. 2 AND 3 MECHANICAL CHECKS

Breaker Serial# Size	Place in Cubicle	Megger Control Wire w/Motor, w/o Motor 1000V AC	1000V DC	1000V DC to GND Megger Contact
	Rectifier 1	MOhm	MOhm	MOhm
	Rectifier 2	MOhn	MOhn	MOhn
	Rectifier 3	MOhn	MOhn	MOhn
	Feeder A	MOhn	MOhn	MOhn
	Feeder B	MOhn	MOhn	MOhn
	Feeder C	MOhn	MOhn	MOhn
	Feeder D	MOhn	MOhn	MOhn
	Feeder E	MOhn	MOhn	MOhn
	Feeder F	MOhn	MOhn	MOhn

TEST REPORT (continued

TEST REPORT (continued)

PHASE IIA DC Switchgear/DC Breaker inspection

SUBSTATION:

SERIAL NO: TESYED BY:

DATE OF TEST: VERIFIED BY:

ITEM/REMARK	VALUE	STATUS

1. protection
   a. Long time rip

      Inspection:
   b. Semi-high speed trip sensor

      Inspection:
   c. Semi-high speed trip test/loss of ac
      1) Instantaneous forward
      2) Instantaneous reverse
      3) Rate of rise
   d. Initial setting
      1) Direct acting These settings are to be set per CTA

         Recommendations
      2) Instantaneous forward
      3) Instantaneous reverse
      4) Rate of rise
   e. Reverse current relay operation

      Remarks: Rectifier breaker only
2. Breaker electrical close and open

TEST REPORT (continued)

PHASE IIA **DC Switchgear**
(Line-Up)

SUBSTATION:
SERIAL NO: TESTED BY:
DATE OF TEST: VERFIED BY:

ITEM/REMARKS	VALUE	STATUS

1. DC breaker trips

   (See Breaker Sheet)
2. 64 device

   a. Hot structure (Pickup__V dc: Circulating Current_____ mA)

   b. Ground structure (Pickup _____ Vdc: Dropout_____ Vdc:

   c. Circulating Current_____mA)

3. Breaker electrical operation
   (See Breaker Sheet)

4. Breaker all mechanical/electrical interlock all positions

5. Kirk key interlock if necessary

6. Interchangeability non-interchangeability all cubicles

7. Reclosing module all positions
   (See Reclose Sheets)

TEST REPORT (continued)

PHASE IIE DC Switchgear Reclosing Module

SUBSTATION
SERIAL NO: TESTED BY:
DATE OF TEST: VERIFIED BY:

	ITEM/REMARK	VALUE	STATUS
1.	Functional Check		
	a. Loss of ac power		
	b. Station bus transducer		
	Above setting		
	Below setting		
	c. Tie condition		
	d. Third rail monitor		
	e. Local measuring		
	f. Unsuccessful closure (breaker closure time)		
	g. Lookout timer		
	h. Number of reclosures		
	i. Load measure delay		
2.	Initial Settings		
	a. Station bus ok above	V	These are to be set
	b. Load resistance above	Ohms	per CTA
	c. Lock out timer	sec.	recommendations
	d. Number of unsuccessful reclosures	attempts	
	e. Tie conditions if feeder above	volts	
	f. Negative rail compensation limits		
	g. Successful breaker closure time	sec.	
	h. Load measuring repeat delay	sec.	

TEST REPORT (continued)

PHASE IIF Annunciators

SUBSTATION:
SERIAL NO: TESTED BY:
DATE OF TEST: VERIFIED BY:

ITEM/REMARKS	STATUS	VERIFIED BY

1. Annunciator

   a. Test button/lamp check
   b. Horn/silence switch
   c. Flasher
   d. Engraving and position (from drawing)
   e. Review elementary diagram for function check

TEST REPORT (continued)

PHASE 111A **Traction Power Substation**
Pre-Energization Check List

SUBSTATION:
SWERIAL NO: TESTED BY:
DATE OF TEST: VERIFIED BY:

ITEM/REMARK	STATUS	VERIFIED BY

1. Previous test data and
   System elementary diagram reviewed

   a. DC switchgear
      -Phase ID
      -Phase IID

   b. Annunciator and metering
      Phase IIF

TEST REPORT (continued)

PHASE IIIA **Traction Power Substation**
Pre-Energization Check List

SUBSTATION:
SERIAL NO: TESTED BY:
DATE OF TEST; VERIFIED BY:

ITEM/REMARKS	STATUS	VERIFIED BY
2. Final check all connections		
a. DC switchgear -Bus connection -Feeder cables (lugs and crimps)		

TEST REPORT (continued)

PHASE IIIA **Traction Power Substation**
Pre-Energization Check List

SUBSTATION:
SERIAL NO: TESTED BY:
DATE OF TEST: VERIFIED BY:

ITEM/REMARK	STATUS	VERIFIED BY
3. Visually check protective relay Settings against data sheet		
a. DC switchgear -RB No.1 -RB No.2 -RB No.3 -Feeder A -Feeder B -Feeder C -Feeder D -Feeder E -Feeder F	Protection Reclosure	
4. Safety checks		
a. DC feeder breakers -Racked to test -Pad locked open -Red tagged		
b. Negative switched opened and red tagged -Negative switchboard -Rectifier anode switch (R1, R2)		
c. Switchgear access panels and doors closed and tagged -AC switchgear -DC switchgear		
d. Control switches to local		

END OF SECTION

SECTION 34 21 13

TRACTION POWER SERVICE ENGINEER

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 DESCRIPTION

A. This section covers the requirements for furnishing a qualified English-speaking factory trained Service Engineer to ensure the details of field work are properly carried out and the testing is performed in accordance with the various manufacturer requirements and approved testing procedures.

PART 2 - PRODUCTS

2.01 DETAIL REQUIREMENTS

A. The Contractor shall promptly furnish a Service Engineer when requested by the Authority for installation, inspection, testing, and adjustment of the equipment described herein, to insure satisfactory performance, and to instruct a reasonable number of the Authority's employees in the proper use and care of equipment. The costs of the Service Engineer including salary, transportation and other expenses shall be included in the Contract Price.

B. The Contractor shall provide, within seventy two (72) hours after notification by the Authority, a qualified field Service Engineer to commence and continue to conclusion of any work, which is required to be ready for safe commercial operation.

C. The cost of the Service Engineer included in the Contract Price shall include, but not limited to the following work:

1. During the installation after the delivery of equipment supplied herein, the Service Engineer shall spend a minimum of one (1) full day per week at each job site, continued until satisfactory completion of field test. Variations from this schedule and requirements will not be permitted except with the consent of the Authority, or for reasons which the Authority deems are beyond the control of the Contractor.

2. Promptly expedite delivery of material supplied herein required for installation, including the exchange of incorrect material supplied.
3. Promptly identify and make corrections to defects in material, workmanship, or manufacturer of equipment supplied.
4. Promptly identify and make corrections to equipment and material supplied to meet the requirements of this Specification.
5. Promptly furnish supplementary installation instructions when, in the opinion of the Authority the installations instructions supplied are incomplete, ambiguous, or otherwise inadequate.
6. Test, calibrate, and adjust equipment to insure proper operation of equipment as required by the Contractor and this Specification.
7. Insure the manufacturer's written installation instructions are followed and notify the Authority immediately when methods of installation are not satisfactory to the Service Engineer.
8. Test and inspect equipment and certify that equipment is properly installed and ready for service prior to being placed in service.
9. Arrange for and participate in field tests.
10. Instruct the Authority’s employees in the proper use, care and adjustment of the equipment.

PART 3 - EXECUTION (NOT APPLICABLE)

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASURMENT

A. The work of TRACTION POWER SERVICE ENGINEER will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the work of TRACTION POWER SERVICE ENGINEER must be included in the contract lump sum price as shown in the Schedule of Prices for Traction Power Work.

4.03 PAY ITEM ACCOUNT NUMBER

A. Traction Power Work: 340000

END OF SECTION

SECTION 34 21 25

TRACTION POWER CABLES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 DESCRIPTION

A. This section specifies the requirements for providing 500, 929, 1000, 1111, 1500, and 2000 kcmil traction power cables, which are used in the traction power distribution circuit of Chicago Transit Authority's (CTA) Rapid Transit system.

B. Provide new, ethylene propylene rubber (EPR) insulated, thermoset, low smoke, non-halogen cross-linked polyolefin jacketed cables which shall be rated for 2,000 volts, or higher for use on the DC distribution system. The cable shall have excellent heat and moisture resisting characteristics and be rated for 90ºC normal operation in wet/dry locations, 130ºC for emergency and 250ºC for short circuit operation. The cable shall have special fire resistant characteristics. The cable insulation and jacket shall be halogen free. The cable shall be listed and approved by UL where applicable.

C. Procure the cables only from well known experienced manufacturers engaged in regular commercial production of the specified cables. The manufacturer shall have not less than ten (10) years of practical and successful commercial field experience with the EPR insulation and low smoke, non-halogen, cross-linked polyolefin jackets. The manufacturer shall furnish complete technical information to demonstrate that the insulation and jacket meet the requirements of this specification for the type and size of cable involved. Failure to supply satisfactory evidence of this experience shall be sufficient cause for rejection of the manufacturer.

D. Related Sections;

1. Section 34 21 61, General Provisions Traction Power
2. Section 34 24 23, Contact Rail Bonding
3. Section 34 21 41, D.C. Disconnect (Knife) Switches Enclosures
4. Section 34 21 46, Traction Power Cable Lugs
5. Section 34 21 47, Cable Tags
6. Section 34 21 95, Electrical Testing.

1.03 STANDARDS

A. The construction and testing of the cables shall conform to the latest editions of the following applicable standards:

1. ASTM Standard B 8-14 Specification for Concentric Lay Stranded Copper Conductors
2. ASTM Standard D 470-13 Test Methods for Cross Linked Insulations and Jackets for Wire and Cable
3. ASTM Standard D 471-12a Test Methods of Rubber Property – Effect of Liquids
4. ASTM Standard D 573-04 (2015) Test Method of Rubber – Deterioration in Air
5. ASTM Standard D 2240-05 (2010) Test Method for Rubber Property – Durometer Hardness
6. ASTM Standard D 2802-14 Specification for Ozone-Resistant Ethylene-Alkene Polymer Insulation for Wire and Cable
7. ASTM Standard D 2863-13 Test Method for Measuring the Minimum Oxygen Concentration for Candle Like Combustion of Plastics
8. ASTM Standard E 662-15 Test Method for Specific Optical Density Smoke Generated by Solid Materials
9. ICEA S-68-516/NEMA WC8 Standard for Ethylene-Propylene Insulated Wire and Cable
10. ANSI/NEMA WC 70-2009 ICEA S-95-658-2009 Standard for Non-Shielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy
11. IEEE Standard 383
12. MIL C-24643
13. Naval Engineering Standard - 711
14. Naval Engineering Standard – 713
15. National Fire Protection Association 70-2014Edition
16. Underwriter Laboratories 1072

B. Where standards are at variance with each other or with other parts of this specification, the most stringent requirements, as determined by an Engineer from the Chicago Transit Authority, shall apply.

1.04 SUBMITTALS

A. Submit shop drawings showing the cable construction details and cable ratings in accordance with Division 01 Section, Submittals. Also include:

1. Test data from previous tests
2. Suggested cable pulling compound and storage/handling requirements
3. Maximum allowable pulling tension
4. Maximum allowable sidewall pressure
5. Minimum bending radius
6. Size of cable
7. Quantity of cable in feet
8. Cutting lengths in feet
9. Reel size

B. Submit certified test reports for all specified technical data that illustrates the manufacturer's ability to successfully manufacture the cable. Include a detailed list identifying previous users, date cable was supplied, and name and telephone number of references. If the Contractor is unable to provide this information upon request, the manufacture may be rejected.

C. The Contractor shall supply a signed statement that the cable insulation and jacket proposed has been tested for and complies with the requirements of this specification. The Contractor shall furnish a certified copy of the result of these tests.

D. Submit the trade name of the insulation and jacket which is proposed to be furnished on this Contract.

E. Cable identification shall be printed on jacket at 3 feet intervals with manufacturer's name, year of manufacture, conductor size, voltage, insulation and jacket type. The center strand of 500, 1,000, 1,500 and 2,000 kcmil cable shall be stamped at six (6) inch intervals, as follows: manufacturers and customer's (CTA) ID and year of manufacturing.

F. The Contractor shall furnish complete technical information to ensure that the insulation and jacket are compatible for the type and size of cable involved. The Contractor shall quote the insulation and jacket thickness as specified. The Contractor shall have had not less than seven (7) years of practical and successful commercial field experience with the EPR insulation and low smoke, non-halogen, cross linked polyolefin jacket. Failure to be able to supply satisfactory evidence of this experience shall be the cause for rejection of his/her proposal.

PART 2 - PRODUCTS

2.01 INTENDED USE AND STRANDING

A. Cables covered in this section are intended for use in dc traction service operated on a 600 Volt nominal system subjected to additional voltages as may occur on the account of switching and operation of trains and rectifier equipment. Cables shall be suitable for installation in wet or dry locations, in exposed or underground/encased conduits, trays, cable racks, direct buried or exposed.

B. Cable Conductor - The conductor shall be uncoated soft-drawn annealed copper conductor, 98.16% (min.) conductivity at 25 degrees Celsius, Class B stranded compressed concentric round per ASTM B 8. The conductor shall conform to all requirements called for in ICEA S-96-658 for Ethylene Propylene Rubber-Insulated Wire and Cable for Transmission and Distribution of Electrical Energy and in ASTM B-8.

C. Conductor stranding and insulation thickness shall be in accordance with Table 1 of this specification and shall be in conjunction with the size of the cable as called for in the Contract Documents.

Table 1 – Conductor Stranding, Insulation and Jacket Thickness

Size (KCMIL)	Number of Strands	Insulation Thickness (Mils)	Insulation AC Test Voltage (V)	Jacket Thickness (Mils)	Maximum Conductor Resistance (Ohms/1000ft)
500	37	110	10,000	90	0.02197
929	2300 to 2331	90 to 125	11,000	65 to 110	0.0122 to 0.0129
1000	61	125	11,000	110	0.01098
1111	2745 to 2750	115 to 145	13,000	95 to 110	0.0104 to 0.011
*1500	91	145	13,000	110	0.00732
*2000	127	145	13,000	110	0.00549

*Not UL Listed

2.02 INSULATION

A. The cable insulation shall be ethylene propylene rubber (EPR) insulation rated at 90 degrees Celsius wet or dry for normal operation. The insulation shall be rated for 130°C emergency overload temperature and 250°C short circuit temperature.

B. The insulation shall comply with ASTM D: 2802-14 "Ozone-Resistant Ethylene Alkene Rubber Insulation for Wire and Cable". However, relative to Para 5.3.2 of ASTM D 2802, the insulation resistance shall be not less than 100% (not 60%) of that required for the primary insulation based of the thickness of that insulation even if a non-conducting separator is used.

C. The EPR insulation shall conform to the physical and electrical requirements, including moisture and voltage tests, as called for in Tables 1 and 2 of this specification.

D. All test samples shall pass all moisture and voltage tests called for in this specification.

E. The insulation shall strip easily and cleanly from the conductor. An opaque polyester tape is optional and, if used, shall be applied between the conductor and EPR insulation to facilitate ability to strip.

F. The insulation thickness and AC test voltage shall be in accordance with Table 1 of this specification.

2.03 JACKET (SHEATH)

A. Directly over the EPR insulation, provide an extruded layer of flame retardant, thermoset, low smoke, and non-halogen cross-linked polyolefin jacket (sheath). The jacket compound shall have been listed by Underwriters Laboratories (UL) for use with cable rated for 90o C operation (except 1,500 & 2,000 kcmil). The jacket (sheath) shall be black in color.

B. The jacket thickness shall be in accordance with Table 1 of this specification and shall be in conjunction with the size of the cable as called for in the Contract Documents. The jacket thickness shall be circular in cross-section, concentric to the conductor. The minimum thickness at any point shall be not less than 90% of the specified thickness listed in Table 1 of this specification.

C. The jacket shall conform to the physical and electrical requirements, including moisture and voltage tests, as called for in Tables 1 and 3 of this specification.

2.04 SPLICES

A. The contract does not involve substantial lengths of cables. Use single continuous runs of cables. Splices are not allowed.

PART 3 - EXECUTION

3.01 TESTS AND INSPECTIONS

A. The Contractor shall perform tests on the insulation, jacket and completed cables in accordance with applicable standards as listed in this specification. Where standards are at variance with each other or with other portions of this specification, or the cable insulation and/or jacket thickness preclude obtaining samples of sufficient size for testing, special arrangements shall be made with the Engineer. All tests shall be conducted on the cable called for in this specification.

B. The Contractor shall submit, prior to shipment, preliminary certified test reports for review by the CTA inspector. All preliminary certified tests shall be performed with the cable on the shipping reels. The preliminary certified test report shall include the conductor DC resistance, insulation resistance, and physical dimensions of the insulation and jacket (i.e.: minimum, maximum and average thicknesses for each reel). Each preliminary certified test report shall include cable footage identification and reel number. The CTA inspector will utilize this information in selecting the reels that will be witness tested for detailed tests.

C. All tests identified in Tables 1, 2, and 3 shall be performed on the selected reels and witnessed by the inspector. Included in these tests shall be a 70,000 BTU per hour flame test in accordance with IEEE 383 for sizes of cable ordered.

D. The inspector will select a sample at random for testing from each 25,000 feet or less batch produced for each size of cable. In no case shall the samples be taken closer than 1,500 feet apart. The inspector will witness tests on a minimum of 5% of each size of cable manufactured for this Contract.

E. The inspector representing the Authority shall have free entry to the manufacturer's facilities at all times while work on the contract for the CTA is being performed and to all parts of the manufacturer's works which concern the manufacture of the cable. The Contractor shall afford the inspector, without charge, all reasonable facilities to satisfy the inspector that the cable is being furnished in accordance with this specification. Tests and inspections may be made at the manufacturer place prior to shipment. Acceptance of material by the Authority at the manufacturer's plant after inspection means that no apparent reason was found to reject the inspected material. However, the Authority reserves the right to reject all material, after delivery to the Authority, which does not conform to this specification.

F. Prior to the shipment of any cable, the Contractor shall furnish to the Authority three certified copies of the final certified test results which includes the itemized tests required by this section, using procedures as called for by the respective ASTM specifications and any other tests in this section. The Contractor shall furnish dimensional cross sections of each size of cable with the certified test results. The certified test reports shall also include the identification number of each shipping reel and the footage on each reel.

G. The Contractor has the responsibility to ensure that all cables supplied will meet this specification. Cable not in accordance with this specification will be rejected.

H. If the Contractor's final certified tests results demonstrate compliance with this specification and are approved by the inspector acting as a representative for the Authority, the Contractor will be so notified to ship the cable. The Contractor shall not ship cable without approval.

I. To accommodate the inspectors travel requirements, the Contractor shall provide the inspector at least a twenty-one working day notice prior to any scheduled testing.

3.02 INSPECTION COSTS

A. All transportation (air-coach class, or other necessary taxi, bus service, etc.) and lodgings required for testing outside the Chicago Metropolitan Area by Chicago Transit Authority personnel or authorized representatives which are necessary to accomplish the satisfactory inspection of cable ordered on this Contract shall not be included in the Contract price. It is anticipated that one trip for two persons will be made to the manufacturer's plant to inspect the manufacturing process, and one trip for two persons will be made to witness each specified test. In each case, the

cost of first trip to inspect the manufacturing process and as well as to witness the test will be borne by CTA.

B. If problems develop as a result of the Contractor's negligence necessitating additional trips, all expenses associated with these additional trips shall be charged to the Contractor.

3.03 TEST RESULTS AND DATA REQUIRED

A. The following data shall be included in the certified test reports:

1. Type of cable, insulation and jacket (sheath); cable size, conductor stranding and specification number.
2. A statement indicating the cable complies with this specification.
3. Conductor resistance per 1,000 feet.
4. Test results for EPR Insulation per Tables 1 and 2 of this specification.
5. Test results for cross-linked Polyolefin Jacket per Tables 1 and 3 of this specification.

3.04 PACKAGING

A. Cable shall be shipped on non-returnable reels. The length of cable on each reel will be provided by the Contractor.

B. Prior to shipment, cable reels shall be wrapped with cardboard or other approved wrapping complete with an overlay of 2 inches by 4 inches of wood lagging.

C. Cables shall be supplied with the ends capped and sealed with heat shrinkable caps to exclude moisture.

D. Each reel or coil shall carry suitable tags showing name of consignee, address, reel identity, order number, name of manufacturer, and type of cable, size, weight and length.

3.05 DELIVERY

A. All transportation charges, including the transit insurance, to the delivery location shall be paid by the Contractor and shall be included in the Contract price.

B. Handling or re-handling of material, at the Contractor's manufacturing and storage locations, prior to delivery shall be considered incidental to the Contract.

3.06 INSTALLATION

A. General

1. The Contract requires installation of new aerial cables and new cables in new ducts as part of the contractor's work for permanent as well as temporary work. Obtain conduit/duct log from the CTA and confirm that the log matches field conditions by visually checking all runs. Verify that all conduits have a nylon cord and a plug to seal the ends to keep ducts free of dirt and other debris.
2. Continued revenue operation of CTA's transit system during execution of this contract is required. The Contractor shall schedule and perform all work in a manner that this basic requirement is not compromised. No connections to existing operating equipment or circuits will be made without specific authorization by CTA.
3. All work which, in CTA's opinion, affects the operation of the transit system shall be performed during track/power outages or shutdowns in such a manner that the system shall be operational when the revenue service is resumed.
4. Install dc traction power cables as shown on the Contract Drawings.

B. Cleaning Ducts

1. Use a flexible rodding device and pass it through each conduit to check for continuity and cleanliness.
2. After rodding, pull a mandrel, which should not be less than ¼" smaller than the inside diameter of the conduit, preceded by a wire brush tied to the same string, through the conduit, once in each direction. If any difficulty is encountered in passage of the duct rodding device or mandrel, a series of wire brushes shall be drawn through the conduit, once in each direction, using a trailing line. Continue with the wire bushes until the final brush is 1/8"diameter less than the inside diameter of the conduit. If the correct size cannot be passed through on the initial pull, the operation must be repeated until accomplished.
3. When the conduit is partially or fully obstructed with mud, dirt, or gravel, the duct must be flushed clean with water using flushing nozzle which should be pushed into the conduit and applied until the duct is clear. After cleaning, follow the procedure outlined above for the rodding and wire brushing.
4. After all obstructions have been removed and the conduits wire brushed clean, pull a nylon cord of suitable strength into each cleaned conduit and attach to the nearest pulling eye with a six foot length left at each end. Immediately upon completion of installation of the nylon cord, both ends of the conduit shall be plugged to prevent entry of foreign matter before the cables are pulled.
5. If the duct is not cleared in spite of performing duct cleaning and rodding operations as described above, the Contractor shall immediately give written notice to the CTA with the field measurements from each end to the point of blockage. CTA will advise Contractor on how to proceed.

C. Installation and Protection of Cable

1. Strip cable reels of all nails on outside edges of reel heads before pulling of cable. Conveniently locate reels for feeding cable without excessive bending or possible injury to cable by abrasion on concrete or sides of duct. Jack reels by at least 6 inches to clear ground level before pulling of cable.

2. Attach pulling ropes to cables with ball bearing swivels to prevent twisting of cable during pulling.
3. Pull cables only after conduits have been cleaned, rodded, mandrelled, and are free of all obstructions. Pull cables after authorization is received from CTA. Pull only one cable into each duct or conduit.
4. Cable-ends shall be sealed per manufacturer's recommendations before pulling into ducts. The ends of cables when cut shall not be left with the insulation exposed to moisture. Protect cables until proper termination or lug is installed.
5. Use the installation method recommended by the cable manufacturer utilizing an approved cable grip.
6. Pull cable into ducts/conduits under moderate tension. Manufacturer's recommended maximum pulling tensions shall not be exceeded. Pulling tension shall be measured and documented.
7. Any lubricant used shall not have a deleterious effect on the conductor insulation or jacket. Use cable pulling compounds which are recommended by the cable manufacturer. Do not use petroleum jelly.
8. Use sufficient personnel between the reel and the duct entrance during pulling operation to inspect, control, and direct passage of cable. Ream duct/conduit mouth where applicable and equip with a fair lead to prevent chafing of the cable.
9. Minimum bending radii as measured to inside surface of the cables shall not be less than those recommended by the manufacture, or not less than eight times the outside diameter of the cable, whichever is the larger.
10. Do not allow cable to chafe on the ground, concrete or sharp surface during pulling. Provide timbers and flexible cable pulling tubes to guide and protect the cable, where necessary.
11. Install duct shields to protect cable at the duct mouth. Use split nylon tube or equal.
12. Label all cables, as required by CTA, with printed numbers on cable tags at all terminal points and duct entrances. CTA will provide cable numbers as requested.
13. Install cables with freedom of horizontal movement to accommodate expansion and contraction of the cables in the ducts.
14. Do not work on energized cables.
15. No fireproofing tape is required.
16. Inform CTA about any field conditions encountered which are not covered or differ substantially from those shown or specified in the contract documents. Perform the work in question in accordance with CTA's instruction.

D. Connection of the Cables to the Contact Rail

1. Connect the positive cables to the contact rail as shown incontract drawing. Provide heat shrinkable tape on the exposed portion of the cable as shown on ET-07118 (STP-118).Use lugs and make connections as shown in contract drawings.

3.07 TESTING

A. Upon completion of the installation of each cable, test the cable insulation as recommended by the manufacturer or as directed by CTA.

B. If no specific test is recommended, test the cable by 1000 V megger. The insulation resistance should not be less than 3,000 megohm divided by the cable length in feet.

C. Do not energize the cables until approved by CTA.

Table 2 – Ethylene Propylene Rubber (EPR) Insulation

Requirement/Test	Applicable Standard	Requirement	Additional Requirement
Operating Temperature, Normal		90°C	Dry or Wet
Unaged Tensile Strength	ASTM D470	1,200 psi, minimum	
Unaged Elongation at Rupture	ASTM D470	250%, min.	
Original Set Maximum	ASTM D470	50%, maximum	
Hot Creep Test (ICEA T-28-562) Elongation Set	ASTM D470	 50%, maximum 5%, maximum	Condition at 150° +/-2 Celsius Sample shall be from completed cable.
Tensile Strength after 168 hours at 121° C, Air Oven Test	ASTM D470	75% of the unaged value, min.	
Elongation after Air Oven Test	ASTM D470	75% of the unaged value, minimum	
AC Voltage Test	ICEA S-96-659, Table 4-2	13kV, 5 minutes	Perform tests in watertank on selected completed reels of cable after 6 hours of immersion and while still immersed

Requirement/Test	Applicable Standard	Requirement	Additional Requirement
DC (Triple AC) Voltage Test	ICEA S-96-659, Table 4-2	35kV	Perform tests in water tank on selected completed reels of cable after 6 hours of immersion and while still immersed -
Insulation Resistance K Constant for Insulation Resistance	ICEA S-96-659, Table 4-5 ICEA S-68-516, Table 3.1	30,000 MΩ/1,000 ft	Perform tests in water tank on selected completed reels of cable after 6 hours of immersion and while still immersed
Power Factor after 24 Hours at Room Temperature	ICEA S-68-516	3.5%	
Ozone Resistance test 3 hours	ASTM D 470	Pass	
Moisture Absorption Test	ICEA S-68-516, Method EM 60		Immersed in 75°C±1°C Water
Dielectric constant after 1 day immersion	ICEA S-68-516, Method EM 60	4.5	Note: 75°C requirement, test shall be performed on #14 AWG wire using insulation originating from the same batch compound Mixture
Increase in capacitance 1 to 14 days	ICEA S-68-516, Method EM 60	3.5%	
Increase in capacitance 7 to 14 days	ICEA S-68-516, Method EM 60	2.0%	
Stability factor, after 14 days	ICEA S-68-516, Method EM 60	1.0, maximum	
Moisture Absorption (Gravimetric Method)	ASTM D740	15 mg/sq. inch, maximum	168 hours at 82°C

Table 3 – Low Smoke, Non-Halogenated Jacket

Requirement/Test	Applicable Standard	Requirement	Additional Requirement
Unaged tensile strength	ASTM D470	1,700 psi, min.	
Unaged Elongation at rupture	ASTM D470	150%, min.	
After air oven test (168 hours at 121°C) (i) tensile strength (ii) elongation	ASTM D573	(i) 75% of the unaged value, min. (ii) 60% of the unaged value, min.	
After air oven test (168 hours at 150°C) (i) tensile strength (ii) elongation	ASTM D573	(i) 60% of the unaged value, min. (ii) 60% of the unaged value, min.	
After oil immersion (18 hours at 121°C) (i) tensile strength (ii) elongation	ASTM D471	(i) 60% of the unaged value, min. (ii) 50% of the unaged value, min.	Table #1, No. 2 oil
Moisture absorption, gravimetric method 168 hours at 70°C	ASTM D470	20 mg/in. sq., maximum	
Durometer Shore C, hold for 1 sec.	ASTM D2240	76±4	(Test to be performed on completed piece of 1500 Kcmil cable)
Limiting oxygen index	ASTM D2863	35%, minimum	

Requirement/Test	Applicable Standard	Requirement	Additional Requirement
Smoke density test on materials used in the manufacture of cables Uncorrected/Corrected specific optical density during first 4 minutes of test	ASTM E662		
- Flaming Mode		50/45, max.	
- Non-Flaming Mode		50/45, max.	
Uncorrected/Corrected specific optical density value obtained during 20 minutes of test			Material shall be prepared in slab of 100 Mils thick, plus or minus 5 Mils
- Flaming Mode		200/190, max.	
- Non-Flaming Mode		300/290, max.	
Ozone Resistance Test, 24 hours at 150 PPM	ASTM 470	Pass	
Smoke Index	NES-711	20, max.	Material shall be prepared in slab of 100 Mils thick, plus or minus 5 Mils

Table 3 – Low Smoke, Non-Halogenated Jacket (continued)

Requirement/Test	Applicable Standard	Requirement	Additional Requirement
Acid Gas Equivalent	MIL C-24643	0.1 ppm/mg, max.	Hydrochloric detector tube, with measuring range 0.5 to 25 PPM, similar to National Draeger Tube Part #CH29501
Toxicity Index	NES 713	1.5	
Cold Bend- 24 hours, 8 times cable diameter (at -25°C)	ICEA S-68-516	Pass	
Tear Strength	ASTM D470	35 lbs./in., minimum	
Fluid Immersion Tests			
Hydraulic Fluid (24 hours immersion at 49°C)	MIL-DTL-915/1F		Use Hydraulic Fluid MIL-H-17672
Tensile strength		50% of the unaged value, min.	
Elongation		50% of the unaged value, min.	
Diesel Fuel (24 hours immersion at 49°C)			
Tensile strength		50% of the unaged value, min.	
Elongation		50% of the unaged value, min.	
Lubricating Oil (24 hours immersion at 99°C)			
Tensile strength		50% of the unaged value, min.	
Elongation		50% of the unaged value, min.	
Salt Water (10% by weight)			24 hour immersion at 20°C

Requirement/Test	Applicable Standard	Requirement	Additional Requirement
Tensile strength		90% of the unaged value min.	
Elongation		90% of the unaged value min.	
Methanol	ASTM D471		24 hour immersion at 25°C
Tensile		50% of the unaged value, min.	
Elongation		50% of the unaged value, min.	
Gasoline (24 hour immersion at 25°C)			24 hour immersion at 25°C
Tensile strength		50% of the unaged value, min.	
Elongation		50% of the unaged value, min.	

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASURMENT

A. The work of TRACTION POWER CABLES will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the work of TRACTION POWER CABLES must be included in the contract lump sum price as shown in the Schedule of Prices for Traction Power Work.

4.03 PAY ITEM ACCOUNT NUMBER

A. Traction Power Work: 340000

END OF SECTION

SECTION 34 21 27

SERVICE AND DISTRIBUTION (600 VOLT AC AND BELOW)

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. The work under this section includes the furnishing of all labor, material(s), equipment, and services required for the installation of the electrical work as specified in this Specification including testing of the complete work; and all other construction required to provide a complete workmanlike job.

B. Any additional fittings, conduits or specialties and other appurtenances not shown on the Contract Drawings but required due to field conditions shall be furnished and installed by this Contractor at no extra cost to the Authority.

C. Relocation or rearrangement of equipment within 10 feet of locations shall be done by the Contractor at no additional cost to the Authority, provided that the foundation(s), support(s), or actual equipment items have not been permanently set in place.

D. The Contractor shall, during the progress of all the job, record any and all changes or deviations and at completion of the job, post on Authority's project management web-site, electronic file of "As Built" drawings.

E. In all cases where a device or part of the equipment is herein referred to in the singular number, it is intended that such reference shall apply to as many such devices as are required to complete the installation.

F. All materials shall be new and the best of their respective kinds. The use of other than "prime" grades will not be accepted

G. Cutting and patching, where required to complete electrical work outlined under this Division of the Specifications, shall meet the requirements set forth in other Divisions of these Specifications.

1.03 SUBMITTALS

A. The Contractor may offer products of other manufacturers than those specified herein for CTA's consideration. Submittals shall be made to the Authority for approval. Submit all data necessary to evaluate substitutions offered for approval..

PART 2 - PRODUCTS

2.01 PANELBOARDS

A. AC Distribution Panelboards, furnished and installed by this Contractor as a part of the auxiliary power system at each substation, shall conform to the following requirements:

1. Material:

a. AC distribution Panelboards, furnished and installed by the Contractor, shall be rated for 120/208 volt, three-phase, four-wire solid neutral service.
b. Panelboards shall be factory-assembled with circuit breakers trip ampere ratings, number of poles and arrangement to be shown on auxiliary equipment single line diagrams.
c. Main and branch breakers shall be bolt-on molded case thermal-magnetic, UL listed, 22,000 ampere interrupting rating. Breakers shall have trip free toggle mechanism, positive trip indication and common trip on multiple breakers. The breakers shall be heavy duty industrial type and shall have thermal-magnetic trip units.
d. The Panelboard bus, breaker frame and breaker trip relays shall be as shown on the Contract Drawings. Panelboard neutrals shall be insulated and grounded, so the Panelboards can be used for service entrance equipment. They shall be labeled.
e. All bus connections, wire terminals and contacts shall be silver plated.
f. Panelboards shall be of enclosed dead-front construction designed for surface mounting complete with hinged door and locking hasp. Panelboards shall be constructed of code gauge steel, galvanized after fabrication, and shall be finished in baked gray enamel. Panelboard cabinet box inside dimensions shall not be less than 24 inches wide by 5-3/4 inches deep. A neatly typed circuit directory, enclosed in a steel frame with glass or celluloid covers, shall be furnished for each panelboard.
g. Panelboards shall be General Electric, Cutler - Hammer, Square D or approved equal.
h. The Contractor shall supply the following data on equipment:

1) Panelboard outline drawings, connection diagrams and spare parts list.

B. Lighting Panelboards

1. Lighting Panelboards, furnished and installed by this Contractor as a part of the lighting system at each new traction power substation, shall conform to the requirements listed below:

    a. Lighting panelboards shall be rated 100 ampere, 120/208 volt three phase, 4-wire, solid neutral service. Neutral shall be insulated and grounded, so the panelboard can be used for service entrance equipment.
    b. Branch breakers shall be bolt-in molded case thermal-magnetic, UL listed 22,000 ampere interrupting rating, trip-free toggle mechanism, positive trip indication, common trip of multiple breakers. Ampere ratings, number of poles and arrangement of breakers shall be established by the Contractor.
    c. Cabinet shall be of enclosed dead-front construction designed for surface mounting complete with hinged door and locking hasp. Cabinet shall be constructed of code gauge steel, galvanized after fabrication, and shall be finished in baked gray enamel. Panelboard cabinet box inside dimensions shall not be less than 24 inches wide by 5-3/4 inches deep. A neatly typed circuit directory, enclosed in a steel frame with glass or celluloid covers, shall be furnished for each panelboard.

2.02 OVERCURRENT PROTECTIVE DEVICES

A. Starter Overload Relay Heaters:

1. The Contractor shall select, furnish and install thermal overload relay heaters for motor-amperes given on motor nameplates.

B. Manufacturer's Data:

1. The Contractor shall supply the following equipment data:

    a. Outline dimension drawings and electrical ratings of combination starters.
    b. Wiring and schematic control diagrams of combination starters

2.03 MOTOR CONTROL

A. Fan Motor Starters:

1. The Contractor shall furnish, install and wire for each fan unit, an "across-the-line" combination non-fused disconnect switch/magnetic starter, built in accordance with the latest NEMA standards. Starter shall be rated for 208V, three-phase; 60 Hz service and be minimum Size 1 complete with three overload relays. Starter coil shall be rated 120V ac with one leg fused. Starter enclosure shall be NEMA 1 design.

2.04 CONTACTORS

A. Miscellaneous Heater Contactors:

1. The Contractor shall furnish, install and wire, for each heater unit, an "across-the-line" combination non-fused disconnect switch/magnetic contactor, built in accordance with the latest NEMA standards. Each contactor shall be rated for 208V, three-phase; 60 Hz service, minimum Size 1. The coil shall be rated at 120V ac with one leg fused. Contractor enclosure shall be NEMA 1 design.

B. Automatic Transfer Switches:

1. The Contractor shall furnish and install automatic transfer - isolation switches to switch 120/208 volt, three-phase, four wire, 60 Hz normal and emergency power services to substation distribution panelboards. The transfer switch assemblies shall be three-phase, four-wire (with neutral bar), with ampere rating as shown on the Contract Drawings, 600 volt, electrically-operated and mechanically held contactors (three pole, double throw operation from a common operating shaft). The contactor operation shall be by means of an operator (solenoid or motor drive) and shall be housed in NEMA 1 enclosure for wall mounting. The following operational features shall be included:

   a. Full phase protection.
   b. Time delay override from normal to emergency source (adjustable from one to three seconds).
   c. Test switch.
   d. Auxiliary contacts to indicate switch position; one N.O. and one N.C. required.
   e. Auxiliary contacts to indicate normal power source failure (operate after override delay of one to three seconds); one N.O. and one N.C. required.
   f. Pilot lights to indicate switch in emergency source position (GREEN) and normal source position (RED).
   g. Manual retransfer to normal source.
   h. Switches shall be furnished complete with lugs for power cable connections (cable size as shown on Contract Drawings).
   i. Each switch shall have an integral by pass isolation switch for maintenance.

2. Automatic Transfer Switches shall be ASCO type 940 with optional accessory 22 or approved equal by Authority.

PART 3 - EXECUTION

3.01 GENERAL

A. Installation of overcurrent protective devices, motor controls, and contactors shall be as recommended by manufacturer, in compliance with appropriate codes, and approved by the Authority.

3.02 INSTALLATION OF PANELBOARDS

A. The Contractor shall furnish and install conduit, fittings, wire-ways, boxes, brackets, clamps and other appurtenances and install wiring as required to complete the auxiliary power system in a workmanlike manner

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASURMENT

A. The work of TRACTION POWER EQUIPMENT INSTALLATION will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the work of TRACTION POWER EQUIPMENT INSTALLATION must be included in the contract lump sum price as shown in the Schedule of Prices for Traction Power Work.

4.03 PAY ITEM ACCOUNT NUMBER

A. Traction Power Work: 340000

END OF SECTION

SECTION 34 21 40

TRACTION POWER D.C. DISCONNECT (KNIFE) SWITCHES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. The section specifies requirements for the furnishing and installing of hand-operated knife switches.

B. The Contractor shall furnish and install the hand-operated knife switches for traction power distribution system under this contract, as shown on the contract drawings.

C. Drawings and other specification sections, apply to this section.

D. Related sections: The following sections contain requirements that relate to this section:

E. Section 34 21 65, Traction Power Basic Electrical Materials and Methods.

F. Section 34 21 41, D.C. Disconnect (Knife) Switch Enclosures.

1.03 SUBMITTALS

A. The Contractor's shop drawings shall include switch construction details and the following data on each type of switch to be supplied:

1. A detailed description of the switch and all components furnished.
2. Drawings showings principle dimensions.
3. Voltage rating and ampere rating.
4. Recommended spare parts list.

B. Certified Test Reports

1. Prior to delivery of the switch to the site, the Contractor shall post on the Authority's project management web-site, electronic files of test reports, certified and notarized.

2. Each certified test report shall include all factory production tests as required by this Specification. Each certified independent laboratory test report shall state switch has been tested for requirements noted below.

C. The switch manufacturer shall provide the names and telephone numbers of qualified personnel who may be contacted for technical direction as required in the field.

1.04 QUALITY ASSURANCE

A. The switch shall be designed, tested and assembled in accordance with the latest applicable standards of IEEE, ANSI, UL and NEMA.

B. Where standards are at variance with each other, or with other portions of this Specification, the most stringent requirements, as determined by the Authority, shall apply.

C. The switch shall be listed by an independent, nationally - recognized testing laboratory.

PART 2 - PRODUCTS

2.01 SWITCH DESIGN AND CONSTRUCTION

A. Switch shall be quick-break, single pole, single throw (SPST) or single pole double throw (SPDT) knife switch for vertical panel mounting as shown on the Contract drawings. The switch shall be rated 800 Volts DC, 600 ampere or 1200 ampere continuous service.

B. The switch shall be of a basic design as shown on the Contract Drawings.

C. The switch shall be designed for outdoor installation in a fiberglass enclosure. The ambient operating temperature range is -25 degrees F to 150 degrees F.

D. The switch shall be an open-knife type, without fuse mounted on an isolated base of glass filled polyester (flame-retardant and non-tracking) type GPO-3 material with beveled edges. All isolated base surfaces shall be treated with a moisture inhibitor to prevent wicking.

E. The manufacturer's switch design shall be completely interchangeable with the switch design shown on the Contract Drawings due to the standardization of the switch installation mounting.

F. Cable terminal lug locations shall be as shown on the Contract Drawings.

G. Switch parts shall be adequately braced to prevent the weight of the cables from imparting twisting strains on the jaw or hinge ends and consequent misalignment of the switch.

H. Switch blade shall travel 180 degrees from the closed to open position.

I. The switch blade handle shall be fully insulated and screw into the blade utilizing 11 threads per inch on 5/8 inch diameter for 1200 amp switch and 16 threads per inch on 3/8 inch diameter for 600 amp switch. The handle shall contain the stud which will be somewhat less than 3/4 inch long so that it will fit in the 3/4 inch deep threaded hole contained by the blade. These handle threads will be interchangeable with another type of handle used with this basic switch at other CTA locations.

J. Terminal studs and matching flange nuts shall be of the basic dimensions shown on the Contract Drawings in order that existing cable lugs will fit on this switch. Blade and clip contact studs shall be 3/4 inch-12, 2-1/4 inch long for 600 amp switch and 3 inch long for 1200 amp switch and threaded all the way.

K. The switch blade assembly material shall be hard drawn rolled copper per latest revision of ASTM B152-97.

L. Switch assembly shall be manufactured such that no special tools are required for its maintenance.

M. Spacing of blade and clip terminals must positively match the spacing shown on the Contract Drawing. Similarly, the width of switch bases shall be as shown on the Contract Drawings to permit group installation.

2.02 MATERIALS AND WORKMANSHIP

A. The switch shall be suitably engineered, designed and constructed for safe, proper and reliable operation without maintenance difficulties.

B. Materials and workmanship shall be of the best quality throughout. Failure to comply with this requirement shall be just cause for rejecting the material furnished.

2.03 SWITCH DATA

A. The Contractor shall furnish the following data on each type of switch to be supplied:

1. A detailed description of the switch and all components furnished.
2. Drawings showing principle dimensions.
3. Voltage rating and ampere rating.
4. Certified Independent Laboratory test report stating switch has been tested for requirements noted in Section 3.01, Switch testing, of this Specification.
5. Recommended spare parts list.

2.04 MANUFACTURER

A. Acceptable manufactures shall be Anderson Power Products, Inc., Filmore Inc., Mac Products, Powerswitch Corp. or approved equal.

PART 3 - EXECUTION

3.01 SWITCH TESTING

A. The switch shall be rated for 600 ampere or 1200 ampere continuous service as indicated on the Contract Drawings at 800 volts direct current. The switch assembly shall comply with requirements listed below and noted in latest revision of ANSI Standard ANSI/UL 363-1980. Design test reports shall not be older than 10 years. The switches shall be retested if the tests were performed prior to 10 years.

1. Temperature

   a. The switch shall be capable of carrying its rated current continuously without any part showing a temperature rise of more than 30 degrees C above a 40 degrees C ambient temperature.
   b. The switch to be mounted as in actual service, with connections made using the smallest size of cable having an ampacity equal to the current rating of the switch.
   c. Temperature readings are to be obtained by means of thermocouples. A temperature is considered to be constant when three successive readings, taken at 15 minutes intervals, indicate no change.

2. Overload:

   a. The test potential shall be not less than 1000 Volts DC.
   b. A double throw switch shall be subjected to four overload tests as follows:
      1) With the line connected to the blade side and the load connected to one set of clips.
      2) With the line connected to the blade side and the load connected to the second set of clips.
      3) With the load connected to the blade side and the line connected to one set of clips.
      4) With the load connected to the second set of clips.

   c. A switch shall be mounted as in actual service, and shall be tested with direct current with a non-inductive resistance load.
   d. The switch assembly, when in "closed" position, shall be capable of withstanding a short circuit current test (bolted fault-type) of 50,000 amps minimum for a 50 millisecond time duration.
   e. Tests conducted using alternating current power source will not be acceptable.

3. Dielectric Voltage Withstand:

a. A knife switch shall be capable of withstanding for 1 minute without breakdown, the application of 60-Hz essentially sinusoidal potential of 1000 Volts DC plus twice the maximum rated voltage: (1) between terminals of opposite polarity with the switch closed, and (2) between line and load terminals with the switch open.
b. The test is to be made using a 500-VA or large capacity transformer, where output voltage is essentially sinusoidal and can be varied. The applied potential is to be increased gradually from zero until the required test value is reached, and is to be held at that voltage for one minute. The increase in the applied potential is to be a uniform rate and as rapid as is consistent with the value being correctly indicated by the voltmeter.

4. Mechanical Test:

a. The switch shall remain capable of performing its intended function when operated manually for 1000 cycles.
b. A switch shall be electrically and mechanically operable at the conclusion of the test and not exhibit any wear, grooving, loosening of parts or other effects that could reduce the ability of the switch to perform as intended.

3.02 INSTALLATION

A. Knife switches shall be installed in boxes (described under Section 34 21 41, Traction Power D.C. Disconnect (Knife) Switch Enclosures) and shall be grouped two, three, four or five to a switch box as shown on the Contract Drawings. Switches shall be installed with the blade terminal connecting the cable from the substation.

B. ard knife switches shall be installed in boxes with copper bus connections detailed on the Contract Drawings. Copper bus bars shall be high conductivity, electrolytic (tough pitch) copper for electrical bus bar construction, cold rolled (hard temper), not less than 97.4 percent IACS conductivity. Bus bar joints shall be NEMA Standard drilling, and bolted with silicon bronze bolts, nuts and flat washers, sizes according to the Contract Drawings.

C. Hardware for mounting switches to the boxes shall be slotted 3/8 inch-16 2-1/2 inch long brass round head machine screw with brass nut and SS flat washer.

D. Bus bar to bus bar, lug to switch pad, and lug to bus bar connection surfaces shall be bright and clean and free of oxide.

E. All contact surfaces: bus bar to bus bar or bus bar to cable lug shall be silver-plated. After the bolted connections are made to bus bars, coat the bus joints and cable lugs with oxide inhibitor as manufactured by 3M Co., Burndy "Penetrox E", Anderson Electric joint compound Catalog #155-1Q or approve equal.

F. Bus bar surfaces shall also be silver-plated where bus bar is to be drilled to accept future cable lugs.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASURMENT

A. The work of TRACTION POWER D.C. DISCONNECT (KNIFE) SWITCHES will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the work of TRACTION POWER D.C. DISCONNECT (KNIFE) SWITCHES must be included in the contract lump sum price as shown in the Schedule of Prices for Traction Power Work.

4.03 PAY ITEM ACCOUNT NUMBER

A. Traction Power Work: 340000

END OF SECTION

SECTION 34 21 41

TRACTION POWER D.C. DISCONNECT (KNIFE) SWITCH ENCLOSURES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This section specifies the furnishing and installing of Disconnect (Knife) Switch Enclosures.

B. The Contractor shall furnish and install Disconnect (Knife) Switch Enclosures as shown on the Drawings

C. Drawings and other specification sections, apply to this section.

D. Related Sections: The following sections contain requirements that relate to this section:

1. Section 34 21 40, Traction Power D.C. Disconnect (Knife) Switches
2. Section 34 21 65, Traction Power Basic Electrical Materials And Methods

1.03 SUBMITTALS

A. The Contractor shall post on the Authority's project management web-site for review before fabrication and assembly, the following shop drawings:

1. Detailed shop construction drawings of each size and type of enclosure to be supplied.
2. Shop drawings for structural steel fabrication.
3. All manufacturers' literature including physical and chemical properties and test results for paint materials.
4. A five year written guarantee that the materials will meet all requirements of these specifications.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Enclosures shall be furnished and installed by the Contractor.

B. Enclosure shall be rigid, weatherproof and constructed from fiber glass reinforced polyester resins for use outdoors in highly corrosive atmospheres. Design shall conform in general to NEMA Type 3 construction and be manufactured as shown on the Drawings.

C. Enclosure design shall be of single or double door overlapping style as shown on the Drawings. Door(s) shall be fastened to main enclosure with continuous stainless steel hinges, 12 gauge minimum the full length of the door. Hinges shall be attached using stainless steel rivets with stainless steel back-up washers. Enclosure design shall include complete hinge concealment when door is closed. Door(s) shall be capable of opening through a 180 degree minimum swing. Overlapping door design shall be of tamperproof construction. Door(s) surface area greater than 400 sq. in., shall incorporate fiberglass bracing to prevent door buckling.

D. Main portion of enclosure shall be of one-piece construction with smooth round corners, all seams sealed, and no holes or knockouts. There shall be no gasketed joints except for neoprene memory-type door gaskets which shall ensure a tight seal as indicated on the Drawings.

E. Bottom of enclosures shall be split at the conduit riser location, with the front half of the enclosure bottom removable and attached to the enclosure with stainless steel hardware as shown on the Drawings.

F. Each enclosure shall have a fiberglass drip shield installed to protect door hardware from dripping water, ice/snow build-ups and settling dust. Drip shield shall be attached to main enclosure using stainless steel rivets and stainless steel back-up washers.

G. Each enclosure shall be provided with vents of adequate size (approximately 6 inch x6 inch) to ensure heat dissipation. Vents shall be weatherproof and tamperproof design as indicated on the Drawings.

H. Enclosure door(s) shall include a 3-point door latching assembly to assure positive closure of door(s) to enclosure at three points (top, middle and bottom) as shown on the Drawings. All latch assembly parts shall be insulated with a high dielectric epoxy coating material (15 mil. minimum thickness).

I. Enclosure door(s) shall have a stainless steel door locking hasp assembly, which shall be attached to door enclosure using stainless steel rivets and stainless steel back-up washer, all as shown on the Drawings. Fiberglass reinforcing pads shall be provided where locking hasp assembly is attached.

J. It shall be the Contractor's responsibility to furnish enclosures coordinated with the knife switches mounting details and switch spacing to match cable entrances provided

under this Contract. Enclosures shall require rugged mounting assemblies and strong supports to hold the switches with their attached cables. Where switches are ganged for connection to common bus, the Contractor shall furnish and install copper bus bar where and as shown on the Drawings. Enclosures shall be of sufficient height to allow closing of the front doors when single throw switches are open, and when double throw switches are closed to either position.

K. Bus shall be adequately braced to withstand a short circuit current test (bolted fault-type) of 50,000 amperes minimum direct current for a minimum time of 100 milliseconds.

L. Tests conducted using alternating current power source will not be acceptable.

M. Enclosures not exceeding 12 inch width shall have one front access door; enclosures exceeding 12 inch width up to and including 61 inch width shall have two front access doors; enclosures exceeding 61 inch width shall have three or more front access doors where width of doors on these wide enclosures shall not exceed 20-7/8 inch. On wide enclosures, requiring more than two front access doors, it shall be Contractor's responsibility to locate intermediate vertical hinge supports in location where they will not block access to switches or connections.

N. Each enclosure shall have automatic corrosion-proof condensation drain plugs installed in box bottom. The plastic drain plugs shall be tamperproof design, with stainless steel screening.

O. All contact surfaces including bus bar to bus bar or bus bar to cable lug shall be silver-plated. After the bolted connections are made to bus bars, coat the bus joints and cable lugs with oxide inhibitor as manufactured by 3M Co., Burndy "Pentrox E", Anderson Electric joint compound Catalog #155-1Q or CTA approved equal.

P. Bus bar surfaces shall also be silver-plated where bus bar is to be drilled to accept future cable lugs.

2.02 WORKMANSHIP

A. Each fiberglass enclosure shall be suitably engineered, designed and fabricated to ensure safe, proper and reliable operation, without maintenance difficulties when installed at various locations on the CTA Rapid Transit System.

B. Enclosures shall be fabricated using a "hand lay-up" technique for application of polyester reinforced fiberglass, minimum 1/4 inch wall thickness throughout. Laminates used shall be 40% glass fiber utilizing alternate layers of 1 oz. matt and 16 oz. woven roving and 60% resin. Resin system used shall meet Underwriters' Laboratories 94VE-1 (minimum) flammability rating.

C. Enclosure back panel shall be 1/2 inch thick fiberglass with a 3 inch lip around the perimeter of the enclosure and be part of the back panel.

D. Enclosure exterior finish shall be Pleogen 2907 Iso-Gel, American Colors 66-20060, or approved equal coating (a polyester base material) of 18 to 20 mil thickness. Color shall be OSHA safety yellow.

E. All exterior surfaces shall be treated with a graffiti preventive coating with ABRC "Polyshield" regular.

F. Enclosure interior shall be finished in white fire-retardant gel coat.

G. Materials and workmanship shall be of highest quality throughout fabrication process. Failure to comply with these requirements shall be just cause for rejection of the material furnished.

1. Enclosures, provided they comply with the critical requirements of this specification shall be "Robroy", "Hoffman", "Signature enclosures" or CTA approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. The Contractor shall furnish and install all the material and hardware required for enclosure support frames as shown on the Drawings.

B. All steel shall be ASTM A36.

C. Fabrication and erection of steel shall be in accordance with the latest A.R.E.A. specification for steel railway bridges, except as noted.

D. All welds shall be made with E70 electrodes in accordance with AWS D1.1.

E. All bolts shall be ASTM A325 H.S., size and diameter as shown on the Drawings.

F. All timber shall be Southern Yellow Pine, Dense Structural Grade 85.

G. The material shall be kiln-dried or air-seasoned to moisture content of twenty-five percent (25 percent) or less.

H. The materials shall be pressure-treated with Grade 1 Creosote (distillate) by the Standard Reaping Process to a net retention of eight (8) lbs. per cubic foot of wood and shall be warranted or independently inspected for compliance. The creosote and treating process shall comply with the current issue of standards as published by the American Wood Preservers Association.

I. All enclosures shall be attached to the mounting frames with stainless steel bolts, nuts, square flat washers and lock washers. Bolts shall be 1/2 inch diameter and conform to ASTM A193. The bolt heads shall be placed inside the enclosure.

J. The Contractor shall be responsible for verifying all dimensions prior to ordering material.

K. The Contractor shall coat bolts and washers (inside the enclosure and on the timber side) with 3M "Scotchkote" electrical coating sealant.

L. The Contractor shall seal all bolts, washers and penetrations inside the enclosure with RTV silicone sealer.

M. Contractor shall submit for review and the Authority's approval prior to ordering and/or fabricating material:

1. Shop Drawings for structural steel fabrication.
2. All manufacturers' literature including physical and chemical properties and test results for paint materials.
3. A five year written guarantee that materials will meet all requirements of these specifications.

N. Coat bolts and washers inside the enclosure with 3M "Scotchkote" or RTV Silicon electrical coating sealant.

3.02 NAMEPLATES

A. Each enclosure shall be provided with nameplates on the front doors of the enclosure as shown on the Drawings. Nameplates to be furnished and installed by the Contractor, shall be 2-1/4 inch wide x 4-1/2 inch high, porcelain enameled with a blue background and white numerals and letters. The nameplates shall be attached to the enclosure with slotted panhead brass machine screws, nuts and washers. Interior identification labeling shall utilize 3-7/8" high stenciled number or letters.

B. In general, enclosure nameplates shall be as:

1. Getaway Enclosure: Traction power section numbers with letters A, B, C, etc., shall be on front doors of enclosures at locations of each switch. Inside the switch enclosure, the letters A, B, C, etc. shall identify each knife switch.

C. An example of a nameplate with dimension and details is shown on CTA STP drawings

D. All mounting holes shall be fitted with a resilient grommet under a non-corrosive eyelet to prevent cracking of the enamel during the mounting application.

E. The finished nameplates shall be flat when resting on the non-finished surface.

F. All nameplates shall have full color coverage and shall be guaranteed for outside usage, against fading and defects such as blisters, peeling, cracks, chipping, pin holes and discoloration.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASURMENT

A. The work of TRACTION POWER D.C. DISCONNECT (KNIFE) SWITCH ENCLOSURES will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the work of TRACTION POWER D.C. DISCONNECT (KNIFE) SWITCH ENCLOSURES must be included in the contract lump sum price as shown in the Schedule of Prices for Traction Power Work.

4.03 PAY ITEM ACCOUNT NUMBER

A. Traction Power Work: 340000

END OF SECTION

SECTION 34 21 44

SUBSTATION MISCELLANEOUS STRUCTURAL STEEL

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 DESCRIPTION

A. The Contractor shall furnish and install all miscellaneous structural steel required for the completion of the work as shown on the Contract Documents and specified herein.

B. Included in this work is the furnishing and installation of reinforcing angles for holes in existing bents, "U" clamps, lug angles, dead and clamps, rail tap brackets, and all other miscellaneous steel fabrication necessary for a complete and workmanlike job.

PART 2 - PRODUCTS

2.01 GENERAL

A. Fabrication and erection of structural steel shall be in accordance with the latest AISC Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings and as specified in Section 05 10 30, Structural Steel, of this specification.

B. Welding to existing elevated structure will not be permitted.

PART 3 - EXECUTION

3.01 DESCRIPTION

A. All holes made into structural members shall be drilled full size. Burning and reaming of holes shall not be permitted.

B. All new miscellaneous steel shall be galvanized and shall receive one (1) shop coat of a two-part aluminum pigmented epoxy mastic, 5 mils dry film thickness and one

(1) top coat of aliphatic acrylic urethane, 1.5 mil D.F.T. Top coat color to match existing steel.

C. The Contractor shall field verify all dimensions to existing steel prior to fabricating new steel. The Contractor shall be responsible for the correct fitting of all miscellaneous and structural steel work.

D. Submit shop drawings indicating connections, piece lengths, attachments, erection and fabrication plans, and type of steel and shop primer.

E. Where aerial conduit and/or cables cross alleys or streets a minimum of 14'-6" clearance must be maintained. The Contractor shall supply a shop drawing showing the intended support configuration at the getaway locations where this type of crossing may be required.

F. No solid metallic connection will be allowed from the substation building to the elevated structure.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASURMENT

A. The work of SUBSTATION MISCELLANEOUS STRUCTURAL STEEL will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the work of SUBSTATION MISCELLANEOUS STRUCTURAL STEEL must be included in the contract lump sum price as shown in the Schedule of Prices for Traction Power Work.

4.03 PAY ITEM ACCOUNT NUMBER

A. Traction Power Work: 340000

END OF SECTION

SECTION 34 21 45

SUBSTATION TIMBER

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This section specifies the requirements for furnishing and installing treated timber as indicated on the Contract Drawings and as specified herein these specifications.

B. The work under this section includes furnishing all labor, tools, equipment and incidentals necessary to install the timber.

1.03 Related Sections: The following section contains requirements that relates to this section.

A. Section 34 21 41 – D.C. Disconnect knife Switch Enclosures.

1.04 SUBMITTALS

A. Submit for the Authority's approval, shop drawings and other appropriate documents verifying conformance to applicable specifications for the materials and the treatment required.

PART 2 - PRODUCTS

2.01 GENERAL

A. The Contractor shall furnish and install all treated timber and decking required for the completion of the work as shown on the Contract Drawings and as specified herein.

B. Included in this work is the installation of all dead end timbers, cross arms, and the furnishing and installation of all decking, planking and all other miscellaneous lumber and timber necessary for a complete and workman like job.

C. Unless otherwise noted on the plans, all timber and decking shall be Southern Yellow Pine, Dense Structural Grade 65.

D. The material shall be kiln-dried or air-seasoned to a moisture content of twenty-five percent (25%) or less.

E. The materials shall be pressure-treated with Grade P1 Creosote (distillate) by the Standard Reaping Process to a net retention of eight (8) lbs. per cubic foot of wood and shall be warranted or independently inspected for compliance. The creosote and treating process shall comply with the current issue of standards as published by the American Wood Preserves Association. Boring samples taken to verify penetration shall be furnished to the Authority.

PART 3 - EXECUTION (NOT APPLICABLE)

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASURMENT

A. The work of SUBSTATION TIMBER will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the work of SUBSTATION TIMBER must be included in the contract lump sum price as shown in the Schedule of Prices for Traction Power Work.

4.03 PAY ITEM ACCOUNT NUMBER

A. Traction Power Work: 340000

END OF SECTION

SECTION 34 21 46

TRACTION POWER CABLE LUGS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. The Contractor shall furnish and install cable/wire termination lugs for all traction power and control cables as noted herein.

B. The Contractor shall prepare traction power cable for termination using the cable manufacturer's recommenced method.

C. Contact surfaces at traction power terminations shall be clean and bright and free of oxide and shall be coated with oxide inhibitor when bolted connections are made.

1.03 Related Sections: the following sections contain requirements that relates to this section.

A. Section 34 21 61, General Provisions Traction Power

B. Section 34 21 65, Basic Electrical Materials and Methods – Traction Power

C. Section 34 24 23 Contact Rail Bonding

D. Section 34 21 25, Traction Power Cable

E. Section 34 21 40DC Disconnect (Knife) Switches

F. Section 34 21 41 DC Disconnect (Knife) Switch Enclosures

1.04 SUBMITTALS

A. Submit for the Authority's approval, shop drawings and other appropriate documents.

PART 2 - PRODUCTS

2.01 TRACTION POWER CABLE LUGS

A. Cable lugs used for termination of traction power cables shall be either solder type or bolted compression type as described herein:

B. Solder Lugs:

1. Solder type, straight terminal lugs shall be installed at cable connections to hand operated knife switches and at contact rail taps. Lug construction and material are as detailed on the drawings.
2. Where lugs are bolted together, as in potheads, the hardware shall be 3/4 inch brass bolts and nuts as shown on the drawings. Solder shall conform to ASTM Designation B32 Solder Metal, Alloy Grade 50A, 50 percent tin, 50 percent lead. Soldering shall be non-corrosive.

2.02 CONTROL CABLE LUGS

A. Control cable/wire termination lugs shall be solder-less pressure indented (crimp) type. Lugs shall be insulated eye or ring-tongue type (open or fork tongue type are not permitted). Termination lugs shall be as manufactured by T&B Corp. (STA-KON type), Burndy (small hydrant type), or approved equal.

PART 3 - EXECUTION

3.01 SOLDER LUGS

A. Cable to Straight Lug

1. The Contractor shall cut and skin cable insulation to proper length (approximately 1/8 inch copper exposed beyond lug).
2. The Contractor shall clean cable and lug (inside) with fine wire brush or abrasive pad.
3. The Contractor shall apply non-acid flux (paste) liberally to cable and lug (inside).
4. The Contractor shall put lug on cable (lug has a pre-drilled 1/4 inch diameter hole in top of barrel).
5. The Contractor shall tape lug and cable at connection with friction tape.
6. The Contractor shall heat lug in center until it is hot enough to take solder in molten form at contact.
7. The Contractor shall feed string solder (50:50 ratio of tin and lead), into hole at top of barrel while constantly heating lug until it starts to overflow. Cold solder joints are not acceptable.
8. The Contractor shall remove heat from lug and continue feeding solder until molten solder stops flowing to eliminate air pockets.
9. The Contractor shall let assembly air-cool.

10. The Contractor shall wait until after assembly has cooled down, remove friction tape to see if solder flowed into the bottom of the lug. If not, repeat steps e thru h.
11. The Contractor shall clean assembly with wire brush or abrasive pad. (Make sure lug machine surfaces are clean of excess solder.)
12. The Contractor shall install heat-shrinkable tube (5 inch approx.) at joint.

B. Two, Three or Four 300 KCMIL Bonds to Straight Lug:

1. The Contractor shall clean rim and inside of lug with fine wire brush or abrasive pad.
2. The Contractor shall apply non-acid flux (paste liberally to lug (inside).
3. The Contractor shall squeeze bonds in lug.
4. The Contractor shall put assembly in vice in upright position.
5. The Contractor shall heat lug from bottom up until it is hot enough to take solder in molten form at contact.
6. The Contractor shall feed string solder (50:50 ratio of tin and lead) from rim of the lug while constantly heating lug until it starts to overflow. Cold solder joints are not acceptable.
7. The Contractor shall remove heat from lug and continue feeding solder until molten solder stops flowing to eliminate air pockets.
8. The Contractor shall let assembly air cool.
9. The Contractor shall wait until after assembly has cooled down; check if solder flowed around bonds and lug rim. If not, repeat steps e thru g.
10. The Contractor shall clean assembly with wire brush or abrasive pad. The Contractor shall make sure the lug machine surfaces are clean of excess solder.

3.02 BOLTED COMPRESSION LUGS

A. Bolted compression terminal lugs shall be installed for traction power cable connection to bus bars. Lugs shall be bronze with NEMA standard tongue drilling complete with silicon-bronze bolts and brass self-locking nuts.

B. Lug tongue surfaces, both sides, shall be machined smooth for good electrical contract.

C. The Contractor shall furnish silicon bronze bolts, washers, and brass self-locking nuts (1/2 inch diameter for 1500 KCMIL cable and 3/8 inch diameter for 500 KCMIL cable) for tongue bolting the lugs to bus bars as shown on the drawings. Length of bolts to be determined in field.

D. Contact surfaces shall be cleaned of oxide and made bright metal before assembly.

3.03 CONTROL CABLES

A. The Contractor shall prepare control cable/wire for termination using cable manufacturers and termination lug manufacturers recommended procedures.

B. Any spare conductors shall be left neatly coiled with the ends taped. Spare conductors shall be minimum of 36 inches from cable end.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASURMENT

A. The work of TRACTION POWER CABLE LUGS will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the work of TRACTION POWER CABLE LUGS must be included in the contract lump sum price as shown in the Schedule of Prices for Traction Power Work.

4.03 PAY ITEM ACCOUNT NUMBER

A. Traction Power Work: 340000

END OF SECTION

SECTION 34 21 47

TRACTION POWER CABLE TAGS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 DESCRIPTION

A. All traction power and control cables installed by the Contractor shall be tagged. Cable tags furnished and installed by the Contractor, shall be either "brass" or "nylon" tags as described by locations listed herein.

PART 2 - PRODUCTS

2.01 BRASS CABLE TAGS

A. Brass cable tags shall be 2 inch x 3 inch x 1/4 inch for 1 line or 2 lines designation of information.

2.02 NYLON CABLE TAGS

A. Nylon cable tags, 3/4 inch x 2 inch neatly and legibilty hand marked with indelible ink characters 1/4 inch high and covered by surface film protection.

PART 3 - EXECUTION

3.01 BRASS CABLE TAGS

A. Brass cable tags, 2 inch x 3 inch x 1/4 inch, die-stamped with 1/2 inch high characters shall be attached to cables with 14 AWG solid copper tie wires. This type cable tag shall be used in the substation, at the duct line entrances and above the cubicle enclosures. Also in manholes, at the entrance and exit duct openings, at the top of conduit risers, under passenger stations platform, under structured decks or similar locations where cables will be accessible for inspection and maintenance.

3.02 NYLON CABLE TAGS

A. These tags shall be attached to cables with nylon tie straps. This type cable tags shall be used in switch enclosures, negative return bus enclosures, substation, and all other similar locations where cables are protected by enclosures.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASURMENT

A. The work of TRACTION POWER CABLE TAGS will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the work of TRACTION POWER CABLE TAGS must be included in the contract lump sum price as shown in the Schedule of Prices for Traction Power Work.

4.03 PAY ITEM ACCOUNT NUMBER

A. Traction Power Work: 340000

END OF SECTION

SECTION 34 21 48

SUBSTATION GROUNDING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 DESCRIPTION

A. The Contractor shall furnish and install a complete grounding system for each Substation.

B. The grounding system shall consist of ground wells, ground rods, ground bus, buried and imbedded ground cable, and bonds from the grounding system to equipment.

C. The Contractor shall furnish and install grounding as required to ground and bond transformers, ac switchgear, motors, panels, panel boards, lighting accessories and other electrical devices as required by Code and as indicated on the Contract Drawings.

D. DC Traction power equipment not covered by Code shall be isolated, bonded, or grounded as indicated in the specifications or shown on the drawings.

E. Cutting and patching, where required to complete electrical work outlined under this Division of Specifications shall meet the requirements set forth in other Divisions of these Specifications.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Unless indicated otherwise, insulated grounding conductors shall be copper wire, with type XHHW green 600 Volt rated insulation, sized and installed in accordance with NFPA 70 Code requirements, and as shown on the Contract Drawings.

B. Bare grounding conductors shall be copper wire sized and installed in accordance with NFPA 70 Code requirements and as shown on the Contract Drawings. Bare

ground cable shall be bare Class A, stranded, annealed, high conductivity copper, no less than 97% IACS.

C. Ground rods shall be 3/4 inch minimum diameter stainless steel type 304 rods, 20 foot minimum length in five foot threaded sections.

D. The Contractor shall furnish and install ¼ inch by 2 inch copper ground bus. Ground bus shall be hard drawn, high conductivity rectangular copper bus bar, not less than 97.4 percent IACS and shall meet requirements of ASTM SPEC B133 166 (latest edition for copper alloy 110).

E. Ground well enclosures shall be polymer concrete construction. Loading performance shall comply with ANSI/SCTE 77, tier 8 (minimum) where light loading is expected and tier 15 (minimum) in areas where heavy equipment is used.

F. Cable to cable connectors and cable to bar connectors shall be high copper alloy cast body with silicon bronze hardware.

G. Inaccessible and buried underground connections shall be made with exothermic welds approved for grounding applications.

2.02 GENERAL GROUNDING REQUIREMENTS

A. The equipment ground conductor shall be distinct and separate from the system neutral ground conductor and shall not be used as a load current carrying conductor. The equipment ground conductor shall provide a low impedance path for line to grounded fault currents and bond all non current carrying enclosures together including raceways, fixtures, receptacles, panels, controls, motors, disconnect switches, and exterior lighting standards.

B. Where building type conductors are installed in a raceway, the equipment ground conductor shall have a minimum size conductor of Number 12 AWG copper. Where green insulation is not available, on large size cable, black insulation shall be used and shall be identified with green colored tape at each junction box or device enclosure.

C. Wiring channels, metallic cable trays, metallic cable racks and all metallic conduit including rigid electrical metallic conduit and flexible conduits, shall be connected at each end to the equipment ground conductor.

D. Switchgear and panelboards shall be provided with an equipment ground bus (including lug or screw terminals) and shall be securely bonded to the enclosure.

E. Lighting fixtures shall be securely connected to the equipment ground conductor. A continuous row of fixtures mechanically joined to provide good electrical contact may be considered as one fixture.

F. Motors shall be connected to the equipment ground conductor. Bolts, nuts, and washers shall be bronze, cadmium plated steel, or other non-corrosive material

PART 3 - EXECUTION

3.01 INSTALLATION GROUNDING SYSTEM

A. The intent is to set forth requirements for an effective ground system. The ground system shall be installed so that the line-to-ground circuit has impedance sufficiently low enough to limit the potential above ground to a level that shall ensure freedom from dangerous electric shock-voltage exposure to the persons in the area and to facilitate the operations of the overcurrent devices in the circuit.

B. Total ground grid resistance shall not exceed 1 ohm. The maximum resistance of a driven rod shall not exceed 5 ohms. If a driven rod is found to exceed 5 ohms, additional ground rod sections shall be added up to a maximum depth of 30 feet. If the overall ground grid resistance of 1 ohm cannot be achieved with deeper ground rods using the locations shown on the contract drawings, the CTA shall be notified and the contractor will be provided direction how to proceed.

C. Grounding and bonding of incoming 12.5 kV utility supply conductors and cables shall be done under the direction of ComEd.

D. The entire power and lighting systems shall be permanently and effectively grounded in accordance with the latest issue of NFPA 70 and the Chicago Electrical Code. The items covered shall include but not be limited to panels, motor frames, lighting fixtures and associated switches and other exposed, non-current carrying parts of the electrical equipment and as established by Engineer.

E. In general, the conduit systems may be used as the equipment ground system within the building.

1. Continuity of ground shall be maintained throughout the conduit systems. Where continuity is not maintained the Contractor shall furnish and install a ground wire into the conduit system to maintain ground continuity.
2. Ground bushings and jumpers shall be used wherever the normal conduit termination does not insure continuity of ground.

F. Concealed or inaccessible grounding connections shall be made with exothermic process.

G. Accessible grounding connections shall be bolted or clamp type unless otherwise indicated.

H. Soldered connections will NOT be permitted in the grounding system.

I. Grounding conductors shall be protected from mechanical damage, and shall be supported in an approved manner.

J. Where ground conductors are run in conduit or other raceway, the ground conductor shall be bonded to the conduit or raceway at each end.

K. A #2 AWG ground wire shall be installed from lightning arrestor(s) to the substation ground bus. Where multiple arrestors are mounted in close proximity away from the substation ground bus, a #2 AWG wire loop, terminated to the substation ground bus at each end, may be used to ground the arrestors.

L. Provide buried or imbedded ground loop(s) as indicated on the Contract drawings.

M. Ground rods shall be installed at the locations shown on the Contract Drawings.

N. Unless indicated otherwise, ground rods shall be accessible and complete with ground wells.

3.02 TRANSFORMER GROUNDING

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A. The 120/208 volt system neutrals of auxiliary and control transformers shall comply with NFPA 70 requirements. The neutral conductor shall originate at the grounded wye secondary of each transformer.

B. The secondary winding ground of each auxiliary or control transformer shall be grounded directly to the substation electrical power system ground.

C. Traction power rectifier transformer secondary neutral shall not be grounded.

D. Transformer enclosures shall be case bonded to the substation electrical ground system in at least two locations.

3.03 INSTALLATION OF GROUNDING SYSTEMS

A. Ground rods shall be installed in locations and to the depths as shown on the Contract Drawings. Stainless steel ground rod sections shall be connected using high strength couplings. Couplings shall be compatible with the stainless steel ground rods and not promote differential metals corrosion of any part of the ground rod assembly. Ground rods shall be installed by driving, not by drilling or jetting.

B. All connections below grade shall be made with exothermic welds and protected from corrosion with mastic or epoxy coating. All connections above grade shall be made with bolted connectors. All mechanical connectors shall be high copper alloy cast body with silicon bronze hardware, manufacturer and type as selected by the Contractor and approved by Engineer.

C. Connectors and lugs and their bolts, nuts or screws shall be furnished by the Contractor for connection to all equipment. The lugs, connectors and hardware shall be of material suitable for attachment of the copper ground system to the material to which it is being attached, without the possibility of attack by corrosive atmosphere or electrolytic action.

D. Bar to bar and lug to bar, bolted connections shall be made with silicon bronze bolts, nuts and washers. All connections shall be made electrically clean.

E. Use bonding jumpers and/or grounding bushing (set screw type) at all junction boxes, etc., to provide conduit ground continuity.

F. Permanently connect the ground terminal on each receptacle to the ground conductor or grounding bushing.

G. All grounding cable runs to equipment steel or tray device shall be securely fastened at intervals not to exceed 24 inches. All hardware for fastening shall be furnished and installed by Contractor.

H. After the entire grounding system has been installed, including ground rods and ground loop, the ground system shall be tested by means of approved test procedure to insure that resistance to ground does not exceed 1 Ohm.

I. Ground grid and ground rod installation and resistance tests shall be witnessed by the CTA.

3.04 GROUNDING SYSTEM FIELD TESTING

A. Ground Rod and Ground Grid System Test:

1. Ground system field testing shall be witnessed by the CTA's Testing Engineers.
2. The testing of grounding systems shall be done by an independent testing service employing the 3 point Fall-of-Potential method with a null balance instrument. Meter shall be such that lead resistance is rejected via null balance. Subtraction of lead resistance is not allowed (or necessary).
3. The test meter shall be Associated Research Vibro-ground test set with null balance, James A. Biddle Megger Earth-Tester-Null Balance, or approved equal.
4. A graph of instrument readings versus potential electrode distance shall demonstrate a "flat" portion on the graph. Failure to achieve this will require larger electrode spacing or different test method. Reading obtained on flat or horizontal portion of graph is taken as resistance to earth of ground under test.
5. Ground grid shall be isolated from electrical supply neutral during test.

B. Individual Ground Rods:

1. Individual ground rods when tested separately shall be isolated from all metallic connections, such as from the ground rod to other grounded structures and electrical system neutrals.
2. When there are many individual rods in a local area a graph of resistance "vs" distance to current electrode shall be made for one typical rod to insure proper distance of remote current and potential electrodes.
3. This sample graph shall be done when there is adequate "open earth" in vicinity of rod with 5 or more steps to the graph or as needed to prove

sufficient probe spacing. Distance to current electrode should be 100 feet or greater.

4. The remaining rods can be tested keeping the same or greater current electrode distances and keeping the voltage electrode at approximately 62 percent of the current electrode distance or as indicated by the graph.
5. If fall of potential test method cannot be performed due to field conditions, another test acceptable to the CTA shall be used.

C. Multiple Ground Rod Grids:

1. Multiple ground rod grids shall be isolated from all metallic connections, such as from grid under test to other grounded structures and electrical system neutrals.
2. A graph of resistance "vs" distance to current electrode shall be made for each grid to insure proper distance of remote current and potential electrodes.
3. The graph shall be done when there is adequate "open earth" in vicinity of grid under test with a minimum of 5 steps to the graph. Typical current electrode spacing would be approximately 200 to 1000 feet depending on size of grid.
4. If fall of potential test method cannot be performed due to field conditions, another test acceptable to the CTA shall be used.

D. The Contractor shall employ the services of an independent and qualified testing service company specializing in electrical and ground system testing. The Contractor shall submit the independent testing service company's qualifications to the Authority.

TEST FORM

GROUND ROD RESISTANCE TO EARTH TEST RECORD

1. DATE _____

2. PROJECT NAME _____

3. LOCATION OF TEST _____

4. DRAWING NO. _____

5. GROUND ROD TYPE _____

   DIAMETER _____

   LENGTH _____

6. TEST METHOD _____

   INSTRUMENT TYPE _____

   SERIAL NUMBER. _____

7. REQUIRED MAXIMUM RESISTANCE TO EARTH _____

8. MEASURED RESISTANCE TO EARTH

   ROD1 _____

   ROD2 _____

   ROD3 _____

   ROD4 _____

   ROD5 _____

   ROD6 _____

   ROD7 _____

   ROD8 _____

TEST PERFORMED BY: _____
Signature

TEST WITNESSED BY: _____
Signature

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASURMENT

A. The work of SUBSTATION GROUNDING will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the work of SUBSTATION GROUNDING must be included in the contract lump sum price as shown in the Schedule of Prices for Traction Power Work.

4.03 PAY ITEM ACCOUNT NUMBER

A. Traction Power Work: 340000

END OF SECTION

SECTION 34 21 61

GENERAL PROVISIONS TRACTION POWER

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section details general provisions for electrical work necessary to support the sections, specifying the categories of traction power distribution, substation equipment, building facilities and electrical work. The work under this section includes detail design and furnishing labor, materials, tools, equipment and incidentals necessary to provide, install and test the electrical work.

B. This Section specifies general provisions that are applicable to all Sections of related to traction power. Additional general provisions applicable only to individual Sections are specified under each such Section.

C. The Contract Drawings show the general arrangement required for the installation of equipment, cable tray, and other associated traction power items. The Contractor shall follow these Contract Drawings as closely as possible. Should conditions necessitate any rearrangement, the Contractor shall prepare and submit drawings showing the changes to the Authority for approval before proceeding with the work.

D. Due to the small scale of the Contract Drawings, it is not possible to show all the offsets and detail every point at which exigencies of construction may require special attention. Any additional fittings, conduits or specialties and other appurtenances due to field conditions and / or local code requirements shall be furnished and installed by this Contractor at no extra cost to the Authority.

E. All items, accessories and/or devices necessary for completion and proper operation of any system shall be designed and provided by this Contractor or Subcontractor for such system whether or not they are specifically called for by Specifications or Drawings.

F. Relocation or rearrangement of equipment within 10 feet of locations shown on the Contract Drawings, when directed by the Authority, shall be done by the Contractor at no additional cost to the Authority, provided that the foundation(s), support(s), or actual equipment items have not been permanently set in place.

G. At the conclusion of the work, the Contractor and a manufacturer's representative shall demonstrate and explain to the Engineer the function, operation and maintenance of all equipment and systems installed.

1.03 SCOPE OF WORK

A. Detail Scope of Work

1. The work shall be performed in stages to facilitate the minimum interruption for Authority's Schedule Service. The work, which requires interruption of service, shall be conducted only at night or during the week-ends to minimize the inconvenience of CTA's riders. The work under this Contract includes furnishing design services, labor, materials, equipment, tools and incidentals for performing all operations as described. See Division 01 Section, Summary of Work, Project Description.
2. The Contractor shall furnish all equipment and perform all work integral to final design, construction, testing and commissioning of the project scoped. The work shall include obtaining all necessary permits, site improvements, landscaping, foundations, building structures, underground utilities, electrical and mechanical systems as shown on the Contract Drawings or specified in the Specifications. For detail Elements of Work, see Division 01 Section of this Specification.

1.04 QUALITY ASSURANCE

A. Materials and installation shall conform to the applicable codes and standards.

B. After all equipment, devices and raceways are installed and wires and cables are in place and connected to devices and equipment, the Contractor shall test the system for continuity, short circuit, improper grounds, and other defects. If any defective conditions are present, the Contractor shall make all necessary corrections and retest for compliance.

C. Each major component of equipment shall have the manufacturer's name, address, model number and rating securely affixed in a conspicuous place.

1. The nameplate of a distributing agent is not acceptable.
2. Code ratings, labels or other data, including any that are die-stamped into the surface of the equipment, shall be in a visible location.

1.05 APPLICABLE STANDARDS, CODES, AND REGULATIONS

A. All equipment, material and work furnished and/or installed under this Specification for traction power Substation work, shall conform to all Federal, State or Municipal laws or ordinances, and if any work shown or specified conflicts with such laws or ordinances, this Contractor shall make such changes as are necessary to meet said requirements. The cost of such changes shall be borne by the Contractor and shall be included in the Contractor's original bid. Where any standards shown on the

Contract Drawings or specified herein exceed the minimum standards set by law, the Contractor shall adhere to the higher standard.

B. The Contractor shall obtain all permits, pay all fees, and arrange for all inspections required for the installation of the work under this Division of the Specification.

C. All work shall comply with the latest edition of the applicable standards and codes of the organizations listed below:

1. IEEE – Institute of Electrical and Electronic Engineers
2. AISI – American Iron and Steel Institute
3. ASME – American Society of Mechanical Engineers
4. ASTM – American Society for Testing Materials
5. AWS – American Welding Society
6. IES – Illuminating Engineering Society
7. IPS – Iron Pipe Size
8. ICEA – Insulated Cable Engineers Association
9. NEMA – National Electrical Manufacturers Association
10. ANSI – American National Standard Institute
11. CFR – Code of Federal Regulations
12. FTA – Federal Transportation Administration
13. NEC – National Electrical Code
14. NESC – National Electrical Safety Code
15. NBFU – National Board of Fire Underwriters
16. NFPA – National Fire Protection Association
17. UL – Underwriters' Laboratories, Inc
18. OSHA – Occupational Safety & Health Administration
19. AREMA – American Railway Engineering and Maintenance Association.

D. In addition to the National Codes, the Contractor shall comply with all local codes and standards insofar as they apply to this installation and equipment.

E. Failure to mention any governing codes in this Specification does not relieve the Contractor from adhering to all codes applicable to the work.

F. Electrical equipment and material(s) furnished by this Contractor shall bear the UL label wherever standards have been established by that agency.

G. At the completion of the work, the Contractor shall obtain and turn over to the CTA a Certificate of Inspection indicating approval and acceptance of the work by the appropriate inspection authority.

1.06 SUBMITTALS

A. Pre-Installation submittals of the following types are required for the listed categories.

1. Equipment details for panel boards, wired enclosures.
2. Catalog cuts shall cover common materials and supplies such as conduit, wire, nuts, bolts, etc.

3. Installation drawings shall cover equipment, materials supplies where installation is not adequately detailed on the Contract documents.
4. Complete rating data for all equipment shall be provided.
5. Instruction books, operation and maintenance manuals with spare parts manuals shall be provided.
6. Catalog cuts for all equipment proposed.
7. Cable, wire, Contact Rail, Insulator, and Rail Anchor test reports.
8. Cable connections, lugs, conduits, raceways, supports, and supporting hardware.

B. Post construction submittals are required for the following types of documents:

1. Shop drawing installation drawings shall be updated to" As-Built" status.
2. Unless otherwise noted, three sets of reproducible As-Built drawings shall indicate the actual "as installed" status of all equipment, cables, raceways, supports, controls and materials incorporated into the facility.
3. Test data shall be provided for all equipment and wiring as required by various sections of these specifications.

C. Shop drawings shall include manufacturers' names, catalog numbers, cuts, diagrams and other such descriptive data as may be required to identify and approve the equipment.

1.07 STAGING FOR TRACTION POWER WORK

A. The basic staging for the replacement of the traction power equipment is described on the Contract drawings for each substation. The detail staging for this work as well as power outage for each substation shall be submitted by the Contractor for Authority’s approval.

PART 2 - PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. Materials and equipment shall be new unless indicated otherwise on the drawings and shall be UL labeled where applicable and shall bear the manufacturer's name, model number and other identification markings.

B. Materials and equipment shall be the standard product of a manufacturer regularly engaged in the production of the required type of material or equipment for at least five years (unless specifically exempted by the Engineer) and shall be the manufacturer's latest design with published properties, that meet the specification requirements.

C. Equipment and materials of the same general type shall be of the same manufacturer throughout the project to provide uniform appearance, operation and maintenance.

D. Equipment and materials shall be without blemish or defect and shall not be used for temporary purposes without the Engineer's written authorization.

PART 3 - EXECUTION

3.01 INSTALLATION

A. The Contractor shall perform all work with trained mechanics of the particular trade involved in a neat and workmanlike manner as approved by the Engineer.

B. The Contractor shall perform all work in cooperation with other trades and the approved project schedule to allow speedy and efficient completion of the project.

C. The Contractor shall furnish other trades with advance information on locations and sizes of frames, boxes, sleeves, openings and other items needed for the work, and also furnish information and shop drawings necessary to permit trades affected to install their work properly and without delay.

D. Where there is evidence that the work of one trade will interfere with the work of other trades, all trades shall cooperate and assist in allocating and working out the work space to make satisfactory adjustments and shall be prepared to submit and revise coordinated shop drawings and installation drawing accordingly.

E. With the approval of the Engineer and without additional cost to the Authority, the Contractor shall make minor modifications in the work as required by structural interferences, by interferences with work of other trades or for proper execution of the work.

F. Minor changes in the locations of equipment shall made at the direction of the Engineer prior to rough-in and shall be at no additional cost to the Authority.

G. The equipment shall be installed with ample space allowed for removal, repair or changes to equipment. Ready accessibility to removable parts of equipment and to wiring shall be provided without moving other equipment which is to be installed or which is in place.

H. The Contractor shall refer to the electrical, structural, civil, track, communications, and signal design documents for installations of adjacent systems.

I. The Contractor shall protect the materials and work of other trades from damage during installation of the work provided under this contract.

3.02 TRANSMISSION OF VIBRATION

A. Traction power equipment, conduit, and fittings shall not be mounted to or supported by elements subject to vibration except by method specified here in and/or shown on the drawings.

3.03 INSTALLATION OF WORK FOR OTHER SECTIONS

A. The Contractor shall coordinate all traction power work and shall complete all wiring, conduit, material, and traction power equipment as required for equipment installed under other divisions of these specifications.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASURMENT

A. The work of GENERAL PROVISIONS TRACTION POWER will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the work of GENERAL PROVISIONS TRACTION POWER must be included in the contract lump sum price as shown in the Schedule of Prices for Traction Power Work.

4.03 PAY ITEM ACCOUNT NUMBER

A. Traction Power Work: 340000

END OF SECTION

SECTION 34 21 65

BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 DESCRIPTION

A. This Section specifies all raceways and boxes as well as appurtenances thereto required for all the electrical work required under this Contract, as indicated on the Contract Drawings and as specified herein these specifications.

1.03 SUBMITTALS

A. All materials shall be new and the best of their respective kinds. The use of other than "prime" grades will not be accepted.

B. The Contractor shall specify products of manufacturers for consideration. Submittals shall be made to the Authority for approval. Submit all data necessary for products offered for approval.

C. In all cases, where a device or part of the equipment is herein referred to in the singular number, it is intended that such reference shall apply to as many such devices as are required to complete the installation.

D. Comply with shop drawings, brochures and samples.

1.04 QUALITY ASSURANCE

A. Contractor is solely responsible for the quality control of the work and shall comply with the requirements in Division One sections as well as the regulatory requirements.

PART 2 - PRODUCTS

2.01 RACEWAYS

A. Metal Conduit and Fittings:

1. Material:

a. Conduit shall be thin walled, galvanized steel EMT conduits or galvanized rigid metal conduit (GRC), as shown in the contract drawings. GRC Conduits shall be hot-dipped galvanized steel with uniform chromate coating for added protection inside and outside. Threads, galvanized after cutting, shall be ¾ inch taper National Pipe Thread. GRC Conduits shall comply with the latest revisions of the following specifications and standards: Federal Specification WWC-581 ANSI, C80.1 UL 6 and 1242. EMT Conduits shall comply with the latest revisions of the following Standards: NEMA Standard FB-1, UL Standard 514B and Federal Specification A-A-50553.
b. Each full length of conduit shall bear the UL label.
c. Fittings for metal conduit shall be galvanized malleable iron or steel, and shall be UL listed.

B. Plastic Conduit and Fittings:

1. Material:

a. Plastic conduits shall be polyvinyl chloride (PVC) suitable for 90°C cable and for installation in direct sunlight. For concrete encasement Type I application and for normal duty above ground Type III application, conduit shall be heavy wall Schedule 40. For direct burial Type II application and for heavy duty above ground Type IV application, conduit shall be extra heavy wall Schedule 80. Conduit shall be UL listed and comply with the latest requirements of the NEMA Standards Publication TC-2.
b. Fittings for plastic conduit shall be made from rigid PVC compounds, and shall comply with the latest requirements of the NEMA Standards Publication TC-3.

C. Reinforced Thermosetting Resin Conduit (RTRC) and Fittings:

1. Listing:

a. The conduit shall be listed by UL, Underwriters Laboratories, to the UL 2515 Above & UL 2420 Below Ground standard. All conduit shipped shall contain UL labels.

2. Manufacturing:

a. The conduit shall be fiberglass conduit, also known as Reinforced Thermosetting Resin Conduit (RTRC), manufactured using the single

circuit filament winding process. Multi circuit windings are not allowed. The conduit shall have a winding angle as close as possible to 54.75 degrees. Winding mandrels shall be straight and true so as to produce a non-tapered conduit. Tapering is allowed at the belled end.

b. The resin system shall be epoxy based, with no fillers, using an anhydride curing agent. The fiberglass shall consist of continuous E-glass Grade "A" roving. All additives for flame spread and lowering smoke density shall be halogen free, i.e. not contain chlorine or bromine Carbon black shall be used as ultra violet inhibitor to protect the conduit and fittings during storage and exposure to the outdoors. Conduit and elbows shall be black in color.

c. Curing shall be done using an oven and take place in two steps. The first curing zone shall bring the conduit slowly to the gel temperature. The second zone shall post-cure the conduit at no less than 350° F. The pipe has to be properly cured so that when measuring the glass transition temperature with a differential calorimeter the difference between the first measurement and the second shall not exceed 5° F. The internal conduit and elbow walls shall be smooth and all fibers embedded in the epoxy.

d. All elbows shall meet the nominal radius + or – 2 degrees. The wall thickness shall meet tolerance as shown below and the "Out of Rounds" as shown in NEMA TC 14. All elbows shall have either straight ends or deep socket couplings. All conduits and elbows shall be durably and legibly marked in accordance to NEMA TC 14.

3. Dimensions:

a. Conduits shall be manufactured with the following nominal dimensions:

		Outside Diameter (Inch)	Inside Diameter (Inch)	Wall Thickness (Inch)
3/4"	SW	1.050	0.910	.070
1″	SW	1.315	1.175	.070
1-1/4″	SW	1.660	1.520	.070
1-1/2″	SW	1.900	1.760	.070
2″	SW	2.375	2.235	.070
2-1/2″	SW	2.875	2.735	.070
3″	SW	3.500	3.360	.070
3″	XW	3.500	3.000	.25
3-1/2″	SW	4.000	3.860	.070
3-1/2″	XW	4.000	3.500	.25
4″	SW	4.460	4.320	.070
5″	MW	5.572	5.380	.096
6″	MW	6.627	6.435	.096

b. Conduits shall be manufactured having non-tapered sections except the integral belled ends.

4. Electrical Characteristics (minimum):

Volume Resistivity	3.8×10^{14} ohm-cm	ASTM D257
Surface Resistivity	1.1×10^{14} ohms	ASTM D257
Dielectric Constant	3.5 (at 10^3 cps)	ASTM D150
Dissipation Factor	0.005 (at 10^3 cps)	ASTM D150
Dielectric strength	500 volts/mil	ASTM D149

5. Mechanical Characteristics:

a. The conduit shall have following mechanical strength when tested in accordance with referenced test method:

Tensile strength, axial		11,000 psi	ASTM D2105
Compressive strength		12,000 psi	ASTM D695
Ultimate elongation		2% psi	ASTM D2105
Modulus of elasticity (4" conduit)		$1.4 \times 10^{+6}$ psi	ASTM D2105
Thermal conductivity		2.0 BTU/(ft2)(hr)(°F/in)	ASTM D5930-1
Specific Gravity		1.9	ASTM D792
Glass content		65-75%	API 15LR
Water absorption		1% max	ASTM D570
Barcol Hardness		52-56	ASTM D2583
Coefficient of thermal expansion		1.2×10^{-5} in/in/°F	ASTM 696
Impact Resistance:			ASTM D2444
Size	3/4" SW	20 ft.lbs.	
	1" SW	25 ft.lbs.	
	1-1/4" SW	30 ft.lbs.	
	1-1/2" SW	35 ft.lbs.	
	2" SW	40 ft.lbs.	
	2-1/2" SW	55 ft.lbs.	
	3" SW	70 ft.lbs.	
	3-1/2" SW	80 ft.lbs.	
	4" SW	85 ft.lbs.	
	5" MW	140 ft.lbs.	
	6" MW	160 ft.lbs.	
Stiffness at 5% Deflection:			ASTM D2412
Size	3/4" SW	1,500 lb/in/in	
	1" SW	1,200 lb/in/in	

1-1/4" SW	850 lb/in/in
1-1/2" SW	600 lb/in/in
2" SW	320 lb/in/in
2-1/2" SW	200 lb/in/in
3" SW	140 lb/in/in
3-1/2" SW	85 lb/in/in
4" SW	50 lb/in/in
5" MW	75 lb/in/in
6" MW	55 lb/in/in

6. Joining System:

   a. Conduit Subjected to Changes in Ambient Temperature
      1) The conduit shall be supplied with a bonded coupling or an integral wound bell on one end and a machined spigot on the other end. A two part adhesive, epoxy resin system, designed to permanently bond fittings and joints of conduit shall be properly mixed and applied to the spigot end before joining the conduits together. The adhesive shall be available for use in three different ambient temperatures, 70°F, 40°F and 20°F. The adhesive shall be supplied from the same manufacturer of conduit and fittings in order not to void the listing by UL.

   b. Constant Ambient Temperature
      1) The conduit shall be supplied with a gasketed joining system which can be used for concrete encasement as well as direct burial installations. This gasketed conduit shall consist of a three- ribbed gasket made from water resistant rubber material. The gasket shall be fit into a permanent groove in the belled end of the conduit. Retainer rings etc. are not permitted and shall not be used in order to create the gasket groove.

7. Fire Resistant and Flame Spread:

   a. The conduit shall be UL 2515 Above Ground Listed and shall meet the UL specifications for Above Ground use, i.e. the flame shall extinguish within 30 seconds each time after 4 consecutive applications of 15 seconds and shall extinguish within 60 seconds after the 5th flame application also being 15 seconds in duration.

8. Toxicity:

   a. The conduit shall not contain any compounds that can release halogens, i.e. chlorine, bromine, flour and iodine in more than trace amounts when burning. Following shall be the maximum values when tested in accordance to ASTM E-800:

Gases	Values (max p.p.m.)
Hydrogen Chloride	0
Hydrogen Bromide	0
Hydrogen Cyanide	< 1
Hydrogen Sulfide	0
Ammonia	0
Aldehydes as HCHO	< 10
Oxides of Nitrogen	< 50
Carbon Dioxide	< 12,500
Carbon Monoxide	< 250

9. Fittings and Accessories:

   a. Fiberglass conduit fittings, elbows, and accessories shall be manufactured using one of two manufacturing procedures. The first method shall use the same process, methods, and components as used to manufacture the fiberglass conduit. The second method shall use the compression molding process, Sheet Molding Compound (SMC), for the manufacture of the finished component. The SMC material shall be a vinyl ester resin with +30% reinforcement of glass. The glass fibers shall be approximately 1" in length. The SMC material shall be fire resistant to UL 2515 specifications and shall be halogen free. Plastic duct plugs shall be manufactured from PVC

D. Phenolic Conduit:

1. Use:

   a. Low smoke, zero halogen, heat resistant rigid non-metallic conduit.

2. The Specification shall be adhered to when procuring rigid non-metallic phenolic conduit. The Contractor shall submit certifications of compliance and/or samples of the conduit to be installed. No alternatives to the Specification will be allowed unless approved by the Authority.
3. Extra heavy wall. 0.25 inch nominal.
4. Minimum characteristics:

Property	Value	Testing Method
Temperature Range	-60°F to +1850°F	ASTM E119
(1850°F 2 hours) Vertical Flame Test FT4	passed	CSA 22.2
Surface Flammability	<5	ASTM E162
Tunnel Test, Flame Spread	<1	ASTM E84
Tunnel Test, Smoke Density	<1	ASTM E84
Tensile strength, ultimate	7,000 psi	ASTM D2105
Flexural Strength	>30,000 psi	ASTM D638
Dielectric Strength	150 volts/mil	ASTM D149
Smoke Density, $D_{S4\ min}$	<5	ASTM E662

Smoke Density, D_{max} flaming	<30	ASTM E662
Smoke Density, D_{max} non-flaming	<20	ASTM E662
Water Absorption	<1.5%	ASTM D570
Coeff of Thermal Expansion	$0.51x10^{-5}$ in/in/^{o}F	ASTM D696
Specific Gravity	1.7-1.75	ASTM D792
Barcol Hardness	48-52	ASTM D2583
Glass Content	60-70%	API 15LR
Modulus of Elasticity	$1.2 \times 10^{+6}$ psi	ASTM D2105

5. Toxicity:

   a. The following shall be the maximum values when tested in accordance to ASTM E-800:

Gases	Values (max p.p.m.)
Hydrogen Chloride	0
Hydrogen Bromide	0
Hydrogen Cyanide	< 1
Hydrogen Sulfide	0
Ammonia	0
Oxides of Nitrogen	< 5
Carbon Dioxide	< 10,500
Carbon Monoxide	< 350

E. Flexible Conduit and Fittings:

1. Flexible conduit connections, approximately 18 inches in length, shall be made to all motors and other devices where rigid connection is not practical or advisable.
2. Flexible conduit shall be liquid-tight, consisting of flexible steel construction covered with an extruded jacket of neoprene or PVC. Conduit shall be American Flexible Conduit Company, Anaconda Metal hose Div., Electric-Flex Company or approved equal. Bare "BX" type flexible conduit will not be acceptable.
3. Fittings for liquid tight flexible metal conduit shall be UL listed and approved for grounding.
4. Flexible conduit above 1-1/4 inch trade size shall have grounding conductor run within the flex. Conductor must be sized on the basis of the rating of the overcurrent protective device for the circuit run within the flex, all in accordance witch NEC, US and any local governing codes.
5. All flexible conduits shall have a grounding conductor run inside the conduit, code sized for all circuits indicated.

F. Inserts and Sleeves:

1. General:

   a. Lay out work in advance of construction of slabs or construction of walls. Provide all inserts and sleeves necessary to complete the work.

2. Conduit Sleeves:

   a. Wall Sleeves: Unless otherwise established by Contractor all exterior and interior wall sleeves shall be of fiberglass reinforced epoxy conduit. All exterior sleeves shall be made watertight, using watertight sealing bushings.
   b. Floor Sleeves: Conduits passing through floors shall be sleeved with fiberglass reinforced epoxy conduit and shall be sealed with neoprene rope and caulk. Sleeves shall extend 1 inch above finished floor surface.

2.02 CABLES TRAY SYSTEM

A. Aluminum Tray System:

1. An aluminum cable tray system shall be furnished and installed for control cable routing as indicated on the drawings. System shall be complete and including fittings and accessories as may be required for workmanlike installation.
2. The drawings show the general routing of cable tray system. The exact routing, locations, distances and elevations will be governed by actual field conditions
3. Aluminum cable tray and fittings shall be of standard width with approximately 4 inch deep sides. Rungs shall be 9 inches on center.
4. Trays and fittings shall be fabricated of aluminum throughout and furnished complete with required splice plates and cadmium plated bolts and nuts.
5. Aluminum cable tray system shall be UL classified for use as an equipment grounding conductor.
6. Cable tray systems shall be as manufactured by B-Line, M. P. Husky or approved equal.

B. Fiberglass Tray System:

1. Fiberglass tray system shall be low smoke, zero halogen and shall include, but not limited to straight sections of ladder type cables, bends, tees, elbows, drop-outs, supports and accessories.
2. The drawings show the general routing of cable tray system. The exact routing, locations, distances and elevations will be governed by actual field conditions.
3. Straight section structural elements, side rails, rungs and splice plates shall be pultruded from fiberglass reinforced polyester resin.
4. Pultruded shapes shall be constructed with a surface veil to ensure a resin rich surface and ultraviolet resistance.
5. Fiberglass tray system shall meet the requirements of ASTM E-84, Class 1 flame rating and self-extinguishing requirements of ASTM D-635.
6. Ladder cable trays shall consist of two longitudinal members (side rails) with traverse members (rungs) mechanically fastened and adhesively bonded to the side rails. Rungs shall be 9 inches on center with approximately 4 inch deep sides.
7. Cable tray systems shall be as manufactured by B-Line, M. P. Husky or approved equal.

2.03 WIRES AND CABLES

A. General:

1. Contractor shall install and connect all wires and cables for substation auxiliary power, control, lighting, etc.

B. Cable (600 volt and below)

1. Wire and cable for all controls, for substation auxiliary power and for substation lighting shall be furnished and installed by the Contractor. Conductors, insulating and jacketing materials shall be in accordance with applicable ICEA and ASTM Standards, and shall conform to the following specifications:

a. Multi-Conductor Cable: Multi-Conductor Cables for control and miscellaneous power shall be stranded copper conductor, XHHW, VW-1 flame retardant moisture resistant 600 Volt, cross linked synthetic polymer insulation, rated 90C dry, 75C wet, flame and moisture resistant fillers. Cable shall be suitable for conduit or duct installation, wet or dry locations.

b. Single-Conductor Wire: Single-Conductor Wire for miscellaneous control and power shall be copper conductor, #12 AWG minimum size, stranded conductor, XHHW, VW-1 flame retardant moisture resistant 600 Volt, cross linked synthetic polymer insulation, rate 90C dry,75C wet. Wire shall be suitable for conduit or duct installation, wet or dry locations.

c. Lighting Wire:
   1) Wire for lighting feeders and branch circuits shall be single conductor, solid copper wire, #12 AWG or #10 AWG as required, with XHHW, VW-1 600 Volt insulation. Minimum wire size shall be #12 AWG.
   2) Fixture wire shall be type SFF-1, stranded, tinned copper, silicone rubber insulated, glass braid covering, rated 600 volts, 160 C. Use of wire nut is allowable.

d. Color Coding:
   1) All 208 volt branch circuits shall be color coded with either colored tracers or solid colored jacketing, using black for-"A" phase, red for "B" phase, blue for "C" phase and white for neutral.
   2) All multi-conductor control cables shall be color coded in accordance with ICEA standards S-66-524, NEMA WC-70e

e. Wire and Cable Take-Offs:
   1) It will be the Contractor's responsibility to furnish and install wire and cable as herein specified. The Contractor will be responsible for making cable take-offs for ordering sufficient wire and cable for the project requirements.

f. Cable Manufacturer's Data:
   1) Data to be supplied by the Contractor for each type of size of wire and cable furnished shall include:

a) Number of conductors, materials, stranding
b) Voltage rating of insulation
c) Temperature rating of insulation
d) Insulation material and thickness
e) Jacket material and thickness
f) Overall diameter
g) Weight, lbs/1000'
h) Manufacturer's test report

C. Tray Bonding Tie:

1. Bare conductor cable as shown on the Contract Drawings.

2.04 BOXES for general wiring

A. Junction Boxes:

1. Where necessary to terminate, tap-off, or redirect multiple conduit runs, the Contractor shall furnish and install appropriately designed junction boxes.
2. Unless otherwise noted, boxes not over 100 cubic inches in size shall be standard UL label, pressed steel boxes. Boxes over 100 cubic inches in size shall be constructed as NEC specified cabinets.
3. Covers shall be of same thickness and material as boxes and shall be secured by brass screws or bolts of the similar material. All boxes shall be hot dipped galvanized steel.
4. Unless otherwise noted, box sizes shall be as required by the National Electrical Code or local governing code for the number of conduits and conductors entering and leaving them. Minimum acceptable junction box size shall be 4 inches square by 1-1/2 inches deep.
5. Boxes over 100 cubic inches shall be of oil tight JIC box construction, unless otherwise noted by Engineer with continuous hinge cover.

B. Terminal Boxes:

1. Where necessary for conductor terminations, the Contractor shall furnish and install NEMA 12 type enclosure with continuous hinged covers for indoor installations and NEMA IV for outdoors.
2. All terminal boxes shall be made up from No. 14 gauge galvanized steel. Boxes shall be finished with gray primer inside and outside over phosphatized surfaces.
3. Each box shall be provided with a removable No. 12 or No. 14 gauge galvanized steel panel mounted on collar studs (panels having 400 square inches of surface or more shall be No. 12 gauge).
4. Terminal blocks shall be suitable for the size of wire, voltage and current rating of the conductor being terminated. Blocks shall include standard terminals, mounting rails, barriers, covers, end stop insulating section and clamp, ground clamps and markers. The terminal strip used shall include a minimum of 10 percent spare terminals.

C. Outlet Boxes:

1. Fixture, electrical device, switch and outlet boxes shall be of the cast metal type with integral threaded conduit hubs. Size shall accommodate device noted and be at least 1-1/2 inches deep.
2. Where three more devices are at one location, use multiple gang box. Install one device per gang unless otherwise determined by the Engineer.
3. Boxes shall be furnished with gasketed covers. Covers shall be screw fastened.
4. Surface outlets on exterior walls and in interior locations where exposed to moisture, and where specifically established by the Contractor, shall be cast metal outlet boxes with conduit hubs and matching device plate.
5. Outlets installed back-to-back in the same wall shall be offset 6 inches horizontally from each other.
6. Outlet boxes shall be attached to masonry or concrete construction by use of expansion anchors and to steel beams by use of clamps, bolts, etc.

D. Pull Boxes:

1. Pull boxes shall be furnished and installed by the Contractor to facilitate conductor installation. Pull box construction details shall comply with the same specifications as for junction box construction.
2. In general, conduit runs of more than 100 feet, or with more than three right angle bends, shall have a pull box installed at a convenient intermediate location.
3. All pull box installations by the Contractor are subject to the approval of the Engineer and must be noted on the "as built" drawings.
4. Boxes shall be supported independently of conduits entering them. Brackets, rod hangers, mounting channels or other Engineer-approved supporting methods shall be used.
5. Pull boxes shall be provided with suitable barriers where required. Vertical offset pull boxes shall contain cable supports at turns to prevent cables from resting on corners.

2.05 WIRE CONNECTIONS AND CONNECTING DEVICES

A. Cable and Wire Tags

1. Each cable shall be tagged at both ends and in each pull box or junction box where terminations are made or where the cable passes through. Each conductor of each cable shall be tagged at all terminations with its circuit or wire number.
2. Cable tags, furnished and installed by the Contractor, shall be as described for the locations listed below:

    a. Nylon Cable Tags: Nylon cable tags, 3/4 inch x 2 inch, neatly and legibly hand marked with indelible ink characters 1/4 inch high and covered by surface film protection, shall be attached to cables with nylon ties where cables are indoors or protected by equipment or enclosures.
    b. Wire Markers: Each conductor of multi-conductor control cable or each individual single conductor wire, at the point of termination, shall be identified by plastic-coated or colored plastic, slip-on type wire markers

with factory printed numbers or letters. The factory printed numbers or letters shall not be affected by cleaning solvent. Wire marker designations shall conform to designations on wiring diagrams or to designations on control terminal block marking strips.

c. The Contractor shall furnish three hundred and thirty (330) spare blank cable tags similar to ones described above.

B. Terminal Lugs and Splicing

1. Terminal Lugs:

a. The Contractor shall furnish and install solderless lugs or studs for power, control and miscellaneous cables for his connections. Bolting hardware for all lugs shall be silicon-bronze. Terminal lugs for traction power cables shall be as described in Section 34 21 46. All other terminal lugs furnished for power and ground cables shall be heavy duty, bolted type, of high copper content alloy, complete with silicon bronze bolts, nuts and lock washers. Lugs shall have tongues with either two or four ½"-13 bolts, as specified, spaced per standard NEMA drillings, and four-bolt cable clamps. All contact surfaces shall be machined smooth and silver plated. The lugs for control and miscellaneous cables shall be crimp type. Note that all lugs for control cables shall be insulated ferrule, ring-tongue type (open or fork-tongue are not permitted).

b. All cable lugs shall be of the compression indent type requiring the use of a special tool.

c. Cable lugs shall be as listed by Underwriters Laboratories Inc. or meet UL 486 heating and pullout tests for compression-indent type.

d. Branch circuit conductor lugs for cable sizes #10 AWG and smaller, shall be ring type only with insulated barrel.

e. Branch or feeder circuit conductor lugs for cable sizes #8 to #2 AWG shall be single-hole type.

f. Branch or feeder circuit conductor lugs for cable sizes #2 AWG and larger shall be two-hole type. Bolt hole spacing shall conform to NEMA standards.

g. All enclosures shall be sized to accommodate the specified connectors so that conductors are bent to radii larger than that recommended by the cable manufacturer.

2. Cable Splicing and Termination:

a. Joints in branch circuit wiring shall be made mechanically and electrically secure with solderless connectors as listed by Underwriter's Laboratories Inc., UL 48 or UL 486.

b. Terminal blocks, for control circuit interconnections external to equipment, shall be furnished and installed by this Contractor. These terminal blocks shall be heavy duty, barrier type, 600 Volt rating, #10-32 washer head screw terminals with marking strip.

2.06 NAMEPLATES

A. Each major component of equipment shall have, as a minimum, the manufacturer's name, address, and catalog number, model, style or type on a nameplate securely attached to the item in an area easily accessible to normal visual demands by maintenance and service personnel. Nameplates for electrical apparatus shall conform to the referenced standards and as specified elsewhere in this Specification.

B. Each switchgear assembly, circuit breaker and auxiliary unit, transformer, rectifier, transfer switch, battery charger, panel board, terminal box, and all panel mounted and individually mounted equipment and devices shall be provided with nameplates for proper identification. Panel mounted devices shall be identified in the rear with designations indicated on manufacturer's connection diagrams. Internally mounted devices shall be similarly identified.

C. Nameplates identifying major equipment shall be in accordance with the requirements of the contract drawing ET-07504. Two nameplates shall be provided, one on front, the second on the rear of the equipment.

D. Nameplates identifying ac and dc circuit breaker and auxiliary units shall follow the requirements of drawing ET-07504 unless otherwise specified. Inscription shall include circuit breaker number and service. One nameplate shall be provided on front, the second on the rear of each unit.

E. Nameplates for panelboards, terminal boxes and similar equipment shall have lettering ¾ inch high, minimum, unless otherwise specified.

F. Nameplates for panel mounted relays, meters, control and instrument switches, fuses and auxiliary devices and individually-mounted circuit breakers, disconnect switches, etc., shall have ¼ inch, minimum, lettering, unless otherwise specified. For protective and auxiliary relays, the nameplate inscription shall include device number and function. Nameplates for fuses shall note the type and rating of fuse, polarity and identify the circuit.

G. All nameplates shall be laminated plastic with dull white surface and black core unless otherwise specified. Letters shall be engraved through outer layer to expose black core. All exposed edges shall be beveled. Nameplates shall be fastened with machine screws. Use of self-tapping screws or adhesives will not be permitted.

H. The legends of all nameplates shall be submitted to the Engineer for approval.

2.07 MISCELLANEOUS ITEMS

A. The Contractor shall furnish, install and connect all miscellaneous panels, motor starters, contactors, disconnect switches, push buttons, selector switches, indicating lights, or other control devices including all mounting hardware, unless such devices are definitely specified herein as being furnished by an equipment supplier.

B. The Contractor shall furnish, install and connect all mechanical exhaust and ceiling fans, unit, toilet room and water heaters, sump pump, temperature control panel, etc., as shown on the Contract Drawings.

C. If detailed specifications are not given herein such miscellaneous devices shall be furnished in NEMA Type I push buttons, switches, etc. or type 1A (motor starters) enclosures for indoor service. They shall be approved by the Underwriter's Laboratories, Inc. and so labeled wherever such approved equipment is commercially available.

D. For each miscellaneous device described above, the Contractor shall furnish a suitable non-metallic nameplate, (black with white lettering), not smaller than 1 inch x 3 inches, suitably engraved with the appropriate device name or number. Contractor shall submit nameplate schedule to the Engineer for approval. Nameplates shall be held in place with self-tapping screw--not rivets. If the device itself is too small to support its nameplates, the plate shall be attached to a bracket, column or other support in reasonable proximity to the device.

E. Contractor shall furnish all other miscellaneous material required to complete the installation in a workmanlike manner.

PART 3 - EXECUTION

3.01 INSTALLATION OF CONDUIT AND FITTINGS

A. Conduit runs shall be no smaller than 3/4 inch trade size.

B. Conduit shall be run in straight lines parallel with or at right angles to building walls, partitions, floors and ceilings. When the location of a conduit is not shown on the Contract Drawing, or the location indicated thereon interferes with other work in place or subsequently to be placed, the Contractor shall work out a satisfactory location free from interferences and, subject to the Engineer's approval, shall proceed on the basis of the selected location.

C. In all cases, conduits and fittings shall be located so as to be accessible for maintenance, to permit removal or repairs to equipment to which conduit is attached and so as not to obstruct or inconvenience personnel in performance or operation and maintenance duties. High temperature or damp location shall be avoided to insure proper ventilation. Where a number of conduits are run together, they shall be grouped in a neat and logical manner.

D. When installing metallic conduit, all conduit shall be taper threaded. Use of running threads will not be permitted, including field cut threads. Each conduit shall be threaded to its full thread length in the conduit coupling or conduit fitting hub to ensure good metallic contact for the ground return path. All conduit ends must be cut square and reamed clean of burrs.

E. Before conduit joints are made, the threads shall be cleaned and then coated with anti-seize, electrically conductive compound.

F. Secure all conduits to outlet boxes, junction boxes or cabinets by placing locknuts on outside of box, and locknuts and bushings on inside of box. Conduit terminations 1-1/4 inch and larger shall be equipped with insulating bushings.

G. Conduits and fittings shall be kept clean and dry during installation. Conduit sleeves shall be used where conduits pass through walls, partitions, floors, ceilings and foundations to prevent shear conditions.

H. Conduit hangers and fasteners shall be made of malleable iron (galvanized or cadmium-plated) appropriate in design and dimensions for the particular applications. Metallic conduits, surface mounted on walls and/or ceilings, shall be supported by means of one-hole clamps and clamp backs. Conduits shall be clamped on steel work, where required, with approved clamps.

I. All conduits penetrating building exterior walls, roofs, or membranes shall be provided with a watertight fitting, pitch pocket, flange, or membrane clamping ring to provide a watertight construction.

J. Avoid using bends and offsets wherever possible. Field bends shall be made so as to avoid changing the internal diameter of conduit and so as not to damage its protective coating either outside or inside. Field bends shall be free from kinks, indentations, or flat surfaces and shall be made with approved conduit bending machines or devices. Individual bends shall not exceed 90 degrees and no more than 270 degrees total bend shall be allowed in any one conduit run, except where a pull box is used.

K. Radius of curvature to the inside edge of field bends shall be a minimum of eight-times the trade size of conduit.

L. The Contract Drawings show the approximate routing of the Conduits. Exact routing and termination locations shall be determined by the Contractor in the field, subject to final approval by the Authority.

M. Metallic conduit located at elevation less than 8 feet from finished floor shall not be installed within 6 feet of rectifier and dc switchgear locations.

N. Empty conduits shall be plugged at both ends prior to cable installation.

O. All conduit elbows, offsets and bends shall be uniform and symmetrical. Installation and workmanship shall be of the best quality and skill to provide a firm mechanical assembly.

P. Conduits shall be continuous from outlet to outlet and from outlet to cabinets and junction/pull/terminal boxes with entry secure in such manner that each system shall be electrically continuous. Entry connections shall be made with two locknuts and an insulated conduit bushing or an insulated grounding bushing as required. The locknuts shall electrically connect the conduit to the cabinet or box. Exterior conduit connections to the cabinets or boxes shall be made by using insulated watertight, threaded hubs as manufactured by the Myers Electric Products, Inc. ("Scru-tite" Type), Thomas & Betts Company ("Bullet" Series 401) or OZ/Gedney (type 4Q).

Q. Conduit systems shall be completed before conductors are installed. Conduits shall be firmly fastened within 3 feet of each outlet box, junction box, cabinet, offset or bend, and shall be supported at the intervals listed in paragraph R below:

R. Maximum acceptable support spacing for rigid conduit, in feet, shall be in accordance with the following table:

Conduit size	Wall	Ceiling	Vertical
3/4 inches	5	7	8
1 inch and larger	6	8	10

S. Channel type metal framing systems to support conduit and/or cable systems shall be based on a channel 1-5/8 inches square, No. 12 gauge steel, mill galvanized conforming to ASTM Specification A-525 and shall be furnished complete with all associated or required mounting hardware.

T. Expansion joints shall be provided wherever construction joints occur in the concrete slabs. Conduit runs shall be adjusted so that expansion joints are at right angles to the slab joints.

3.02 INSTALLATION OF PLASTIC CONDUIT

A. Plastic conduit, furnished and installed by this Contractor, shall be installed with plastic fittings in accordance with the conduit manufacturer's instructions. Joining method shall be solvent cement technique to provide strong watertight joints in the conduit system.

B. Exposed plastic conduits shall be supported and clamped as shown on the Contract Drawings. Conduit runs shall be no smaller than 3/4 inch trade size.

C. In general, plastic conduit will not be permitted on this project, except in specific cases where permitted by the Authority.

3.03 INSTALLATION OF REINFORCED THERMOSETTING RESIN (RTRC) CONDUIT

A. Conduit and fittings shall be run in straight lines parallel with or at right angles to building walls, partitions, floors, ceilings, or elevated structure When the location of a conduit is not given on the Contract Drawings or the location indicated thereon interferes with other work in place, the Contractor shall work out a satisfactory location free from interferences and, subject to the Authority's approval, shall proceed on the basis of the selected location.

1. In all cases, conduits and fittings shall be located so as to be accessible for maintenance, to permit removal or repairs to equipment in which conduit is attached and so as not to obstruct or inconvenience personnel in performance of operation and maintenance duties.

B. Conduits and fittings shall be kept clean and dry during installation.

C. When installing fiberglass reinforced epoxy conduit overhead, conduit fittings shall be from the same manufacturer.

D. All conduit elbows, offsets and bends shall be uniform and symmetrical. Installations and workmanship shall be of the best quality and skill to provide a firm mechanical assembly.

E. Conduit routes shown on the Contract Drawings are approximate. Exact routing and termination locations shall be determined by the Contractor in the field subject to final approval by the Engineer.

F. Where aerial conduits cross alleys or streets a minimum of 14 feet – 6 inch clearance must be maintained.

G. All attachments to structure shall be drilled and bolted. No beam clamps shall be allowed.

H. When fiberglass reinforced epoxy conduit is installed under the elevated structure for traction power cable distribution, it shall be 3 inch diameter conduit supported at intervals determined by calculating the total weight of the traction power cable and conduit using the modulus elasticity of the fiberglass conduit. Midpoint deflection shall not exceed 5/8”.

I. Vertical and horizontal expansion capability shall be provided at each elevated structure expansion joint.

J. For fiberglass reinforced conduit installation in encased concrete duct see spec section 34 21 68 Traction power underground ductbank and manholes.

3.04 INSTALLATION OF WIRE AND CABLE

A. Unless otherwise noted, all wire and cable runs external to equipment assemblies shall be installed in conduits.

B. The Contractor shall obtain and observe recommendations of the manufacturer as to installation, care and handling of the various cables. Minimum bending radius shall not be less than that allowed by the ICEA Standards.

C. No splices will be permitted in any power or control cable runs. Cables must be continuous from termination to termination. No splices or joints will be permitted in lighting feeders or branches except at outlets or accessible junction boxes. Joints in branch circuit wiring for conductors not larger than #10 AWG shall be made mechanically and electrically secure using screw-on connectors.

D. Any spare conductors shall be labeled as such and be left neatly coiled, with the ends taped and extending from the cable a minimum of 36 inches.

E. The Contractor's cable pulling shall be in accordance with accepted modern practices so as to prevent damage to the cable. Before pulling cables, a round test mandrel shall be pulled through the duct which is to be occupied, in order to be

sure that it is cleared of all obstructions. The test mandrel shall be of a size especially designed for the duct being tested. The mandrel shall be of the rigid type not less than 12 inches in length and shall have tool-steel cutting ends to remove obstructions. Cable pulling tensions, speed, lubricants and other pertinent factors in connection with pulling and handling shall be in accordance with the cable manufacturer's recommendations, or as approved or directed by the Authority. A cable protector shall be fitted in the end of the duct during pulling operation in order to prevent injury to the cable. The cable shall be fed into the duct through a flexible metal pull-in guide. Where more than a single cable is being pulled in, all cable shall be pulled directly into the duct from the coil or reels on which they are received.

F. Cables shall not be pulled off and laid on the ground prior to installation. Cable grips shall be designed for the purpose and shall not cut or otherwise damage the cable. No cable shall be pulled with ends open. A rubber tape seal shall be maintained at all times. The cable shall be continuously inspected during installation and any cuts, abrasions, or otherwise injured portions shall be brought to the attention of the Authority and repaired or removed as directed.

G. Conductors shall not be drawn into conduit until the conduit is free of moisture. In drawing wires into conduit, sufficient slack or lead shall be allowed to permit the connections to devices without splices.

3.05 CABLE TRAY SYSTEM

A. The Contractor shall adequately protect cables in trays until all construction work is complete. If, in the opinion of the Authority the cable has been damaged by falling objects, welding debris or other reason attributable to construction practices, the damaged cable shall be completely replaced at the Contractor's expense.

B. Cable trays shall be assembled and installed in such a manner as to provide smooth inside surfaces, free from any abrasions which might cause damage to cables. Damaged pieces shall not be used unless they can be removed and straightened in a manner satisfactory to the Authority. All parts shall be installed in such a manner that they will support cable loads for which they are designed.

C. Cable trays shall be adequately supported from walls or underside of roof beams. All trapezes, brackets, clamps, rods, couplings and suspension fittings, expansion shields, hardware and miscellaneous steel shall be provided to insure a complete support system in accordance with recognized high quality practice.

D. Tray routing shall be adjusted in the field to clear interferences with installation of other trades. Any rerouting of trays to clear interferences shall be subject to prior approval of the Authority.

3.06 FIBERGLASS CABLE RACK SYSTEM

A. The Contractor shall furnish and install low smoke, zero halogen fiberglass cable rack system for support of 600V DC cables within the building. Individual support

racks shall be made up of fiberglass unistrut channel members, clamps and associated accessories as required to complete the installation in a workmanlike manner. The fiberglass strut system shall meet ASTM E-84, Class 1 flame rating and self –extinguishing requirements of ASTM D-635.

B. Cable support racks shall be B-Line, M. P. Husky, or approved equal.

3.07 CABLE SUPPORTS ON STRUCTURES

A. Contractor shall furnish and install cable support racks on the elevated structure as shown on the Authority Standard Drawings. Cable support racks shall be heavy-duty construction consisting of hot- dip galvanized steel mounting brackets and horizontal, creosoted wood timber members for cable attachment. Hardware for rack assembly and to hold the cable clamps shall be galvanized steel. Cable support rack locations and installation details shall be as shown on the Authority Standard Drawings.

3.08 CABLE SUPPORTS IN THE MANHOLES AND IN THE SUBWAY

A. Unless otherwise noted within this specification or shown on drawings, the Contractor shall furnish and install non-metallic cable support racks in the manholes, splicing chambers and similar other locations where cables are to be in open runs supported from racks. Cable support racks and mounting channels shall be heavy-duty construction, consisting of molded, fire retardant, non-corrosive glass reinforced nylon with high dielectric properties.

B. Mounting channels shall be surface type and shall be anchored to concrete with stainless steel, heavy duty, one piece, wedge type concrete anchor bolts with nut and washer. Length of anchor bolts shall be long enough to exceed the minimum embedment in concrete, recommended by the anchor bolt manufacturer.

C. Cable will be tied to the cable racks with cross-wise nylon cable ties at each rack (two ties at each point of support).

D. Cable support racks shall be "Underground Devices" Cat. No. RA20 or approved equal.

E. Cable rack channels shall be "Underground Devices" Cat. No. CR36 or approved equal.

F. FILLING OF OPENINGS

G. Where conduit and raceway pass through fire-rated walls, ceilings or floor, provide seals to prevent passage of fire and fume and to maintain integrity of fire-rated structure.

H. Close unused openings or spaces in floors, walls and ceilings. Plug or cap unused conduit and sleeves.

3.09 IDENTIFICATION

A. At end of each run, use brass with stamped markings to establish identification of conduit, raceway and ducts.

B. Test metallic conduit and boxes for electrical continuity. Conduct tests in presence of Authority and record results in writing.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASURMENT

A. The work of BASIC ELECTRICAL MATERIALS AND METHODS will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the work of BASIC ELECTRICAL MATERIALS AND METHODS must be included in the contract lump sum price as shown in the Schedule of Prices for Traction Power Work.

4.03 PAY ITEM ACCOUNT NUMBER

A. Traction Power Work: 340000

END OF SECTION

SECTION 34 21 70

SUPERVISORY CONTROL EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 DESCRIPTION

A. This part of the specification covers the cabling and software configuration modifications to the supervisory remote terminal units (RTU's) for control, supervision, and data capture of additional traction power substation equipment at the Washington Boulevard Substation.

B. In addition, all software configuration modifications shall be provided to the existing master station at the CTA's Communication Center to accommodate the upgrades at the Washington Boulevard Substation as shown on the Drawings and in these Specifications.

C. The Contractor shall coordinate with the Authority all work at Washington Boulevard Substation and at CTA's Communication Center.

PART 2 - PRODUCTS

2.01 DESCRIPTION

A. Furnish the following:

1. It is anticipated no additional equipment at the Control Center master station.
2. Internal wiring within the existing cabinets at Washington Boulevard Substation.
3. One (1) year warranty, starting on the day of Final System Acceptance, on all WORK provided under the Contract.
4. Delivery of all material and documentation (including software source code).
5. Instruction manuals, operating instructions, maintenance manuals, drawings (on diskette-AutoCAD format), termination (wire-marking) diagrams, software documentation and all other appropriate documentation, representing the final configuration (or version) of hardware and software as installed in the field and accepted by the Authority. All manuals shall be in English and written in a clear

and concise manner such that a person of average technical background can easily understand and use them.

6. System start-up assistance (labor and material) during field check-out and acceptance tests (field acceptance test and availability tests), and correction of all defects discovered during field acceptance and availability tests.
7. Field start-up, check-out, training and acceptance of the operational system with the assistance of the Authority.

B. General Requirement of SCADA System

1. General

a. All work detailed in this section shall be furnished, configured and tested such that upon completion of work by the Contractor/Manufacturer, this additional portion of the SCADA system shall operate and be functionally equivalent to the present system.
b. It shall be the sole responsibility of the contractor/manufacturer to completely understand the Authority's present SCADA system, C/PC operations and field operations such as to complete this project with minimum impact to the CTA's day-to-day operation.
c. All equipment to be furnished under this contract shall be in accordance with the latest applicable standards of NEMA, IEEE, ANSI, U.L., NEC and all applicable Local, County and State Codes and Regulations. Where conflicts occur, the decision of the Authority's Project Manager will be final.
d. Where any requirements specified herein exceed those standards listed, the contractor shall adhere to the Specification.

C. Remote Terminal Unit (RTU) Modifications

1. The Contractor shall provide additional I/O points as shown on the Drawings. This shall include internal cabinet cabling and RTU programming.
2. Interposing Relays

a. For each control point, two (2) interposing relays shall be provided, unless otherwise specified. One shall energize in response to a trip or stop code sent from the master station, the other energizing in response to a close or start code.
b. The interposing relays shall be industrial type and have two (2) form 'C' contacts (two (2) make and two (2) break contacts) with a continuous current-carrying capacity of 10 amperes at 150V dc nominal voltage. The interposing relays shall operate at 48 or 24 volts dc, and shall withstand 48V dc continuously without overheating. The interposing relays shall have dust-tight, easily removable covers and shall be of the semi-flush mount type. All interposing relays shall be Potter & Brumfield series KUEP or approved equal. The interposing relays shall be Westinghouse Electric Corporation Type SG Auxiliary Relays or approved equal.
c. All interposing relays furnished and installed complete with all necessary wiring. All interposing relays shall be mounted inside the existing RTU cabinet.

d. The power transfer relay (device 283) shall be an industrial type having four (4) make and four (4) break contacts with a continuous current carrying capacity of 12 amperes each, an interrupting capacity of 3 amperes non-inductive at 125V dc and 8 amperes non-inductive at 48V dc. The power transfer relay shall be Westinghouse Electric Corporation Type MG-6 multi-contact auxiliary relay (complete with cover) or approved equal. The 283 power transfer relay shall operate automatically upon loss of normal power supply, through its contacts, and will disconnect the RTU equipment from the primary power source and connect it to the backup power supply. Upon restoration of normal power supply, the power transfer relay shall switch the RTU equipment back to the normal power supply. The position of the power transfer relay shall be supervised by internal wiring to give an alarm indication on SCADA if the device is not in its normal position.

e. The emergency close relay device 201D, shall be an industrial type relay having four (4) make and four (4) break contacts with a continuous current-carrying capacity of 2 amperes each, and interrupting capacity of 3 amperes non-inductive at 125V dc and 8 amperes non-inductive at 48V dc. The emergency close relay shall be a mechanical latch relay which holds the armature in the operated position until the latch is tripped mechanically or electrically. An operating coil cut-off contact shall be supplied with the electric reset. The emergency close relay is a controllable device that can be energized or de-energized through the SCADA Master Station. An mechanical adjustable timer from zero (0) to thirty (30) seconds shall be included to reset or clear the latch ready after it was set (so the resetting command from the SCADA Master Station is optional). The emergency close latch relay shall be Westinghouse Electric Corporation Type MG-6 multi-contact auxiliary relay (complete with cover) or approved equal. The position of the power transfer relay shall be supervised by internal wiring to give an alarm indication on SCADA if the device is not in its normal position.

3. RTU Supervision

a. The supervision of all devices shall be accomplished via the monitoring of dedicated auxiliary contact(s) on each device. The auxiliary contact(s) will open or closed depending on the status of the device (open, closed, running, etc...). The RTU shall monitor the position of the contact(s) and report the status of the device to the master station. The status up to three (3) auxiliary contacts ("A", "A1", and "A2") shall indicate a maximum of eight (8) possible positions of the device.

b. The RTU shall be equipped with local indications that will display the state of each and every contact with configuration as "energized in normal".

4. RTU Control

a. Control of circuit breakers and other devices shall be accomplished by closure of the close or trip interposing relay associated with each controlled circuit breaker or device. The contact of the interposing relays shall make and break circuits from the respective control voltage

5. Wiring

   a. All wiring shall be stranded and of suitable gauge and insulation to meet the intended use. Extra flexible stranded control wires shall be used for wiring between hinged and stationary portions of panels. All internal wiring to interposing terminal blocks shall be a minimum of #14 AWG stranded wire.
   b. Input and output wiring shall be kept physically separate where possible. AC and low voltage dc wiring shall be kept physically separate where possible.
   c. All wiring shall be clearly identified, with destination, at both ends using white plastic slip-on markers with etched black lettering. The marker diameter shall be consistent with the wire diameter to insure a snug fit, but yet able to be rotated for identification.
   d. All wiring shall be secured into harnesses. All wiring including harnesses shall be routed in such a manner as to not obstruct the installation or removal of RTU components, and shall be secured to the cabinet where appropriate for neatness and to reduce strain on components.
   e. All terminations to terminal strips within all RTUs shall be made with crimp-on insulated ring type terminals.

6. Input/Output Isolation and Protection

   a. All inputs and outputs including power supply and circuit ports shall be capable of withstanding the IEEE SWC standard test without damage.

7. Appropriate transient protection shall be provided for each RTU on all communication circuits and other input sources. These protection schemes shall be approved by the Authority's Project Manager prior to construction of any RTUs associated with this project.

PART 3 - EXECUTION

3.01 INSPECTION, TEST AND AVAILABILITY

A. Field Acceptance Test

1. After the equipment furnished in accordance with these Specifications has been installed and made ready for operation by the Authority, the Contractor shall within five (5) days at his own cost and expense, furnish a competent English-speaking Engineer who will inspect the installation, make any necessary adjustments and cooperate with and assist the Authority in making field tests on the equipment furnished.
2. These field tests shall consist of the repeated operation of each function required by these Specifications, with representatives of the Contractor and the Authority present to observe each piece of equipment involved, until sufficient satisfactory operations are obtained as determined by the Authority.
3. Following successful start-up of the SCADA existing master and all RTUs, Contractor personnel shall proceed to reconduct most of the factory test and

conduct appropriate new tests. Any problems encountered during these tests shall be corrected at Contractor's expense.

4. If the system fails to pass the Field Acceptance Test within a ninety (90) day period or within such longer period as may be mutually agreed to by the Authority and the Contractor in writing prior to the commencement of the Field Acceptance Test, the Authority, within thirty (30) days after such period, may elect one of the following options:

    a. The Authority negotiates with the Contractor for an extension of the Field Acceptance period with proper compensation by the Contractor to the Authority for cost incurred by the Authority due to the delay. This cost shall be determined by computing all CTA (includes fringe benefits and over-time) costs of staffing the affected field locations installed for the project.

B. Availability Test

1. After the completion of the Field Acceptance Test, the system shall be subjected to an availability test for thirty (30) days. All the RTUs shall be included in this Test.
2. The availability shall be 99.9% or greater.
3. This period shall be reinitialized after any significant change as been made to the system.
4. If the availability is determined to be less than 99.9%, the test shall be continued until the specified system availability is achieved over any consecutive thirty (30) day period, or until the test period has exceeded three months at which time the test shall be concluded as unsatisfactory. The Authority shall then elect one the following option:

    a. The Authority immediately discontinues and ceases its use and operation of the system, and terminated the Contract in accordance with the terms contained in General Conditions/Special Conditions.
    b. The Authority negotiates with the Contractor for an extension of the Field Acceptance period with proper compensation by the Contractor to the Authority for cost incurred by the Authority due to the delay. This cost shall be determined by computing all CTA (includes fringe benefits and over-time) cost of staffing the affected field locations installed for the project.

3.02 INSTALLATION OF SCADA EQUIPMENT

A. Submittal

1. Four (4) complete sets of manuals and drawings detailing the installation procedures shall be provided four (4) weeks before shipment of the equipment. This will enable the Authority to prepare, where possible, for the installation.

B. Remote Terminal Unit Interconnection Cables

1. SCADA analog cable between RTU and transducer shall be a shielded one (1) pair of #16 AWG stranded and tinned copper conductors, with stranded tinned copper #16 AWG drain wire and aluminum-polyester shield, EPR insulated, thermoset, flame resistance, low smoke non-halogen cross-linked polyolefin jacket cable, rated at 1000V 90 degree UL listed.
2. SCADA status/control cable between RTU and control/monitor device shall be a #14 AWG seven (7) stranded and tinned copper conductors, with stranded tinned copper #14 AWG drain wire and aluminum-polyester shield, EPR insulated, thermoset, flame resistance, low smoke non-halogen cross-linked polyolefin jacket cable, rated at 1000V 90 degree UL listed.
3. Individual conductor color code for cables to be per ICEA Table K-2:

    a. 2-conductor: black, red
    b. 4-conductor: black, red, blue, and orange.
    c. 7-conductor: black, red, blue, orange, yellow, brown, red and black.

3.03 MAINTENANCE

A. For the Warranty Period, the Contractor shall be fully responsible for all maintenance of Hardware and Software (Authority's staff shall participate under the Contractor's supervision) and following this, a preventative maintenance and servicing contract may be established to a CTA approved company for items such as the computers and standard computer peripherals.

3.04 TECHNICAL SUPPORT EQUIPMENT

A. The Contractor shall furnish any special tools and test equipment specially designed for and required to maintain the computers, peripherals, RTUs and related equipment. This includes, but is not limited to, test sets, card extenders, special cables and plugs, and tools designed to aid in the test, repair, and checkout of the equipment.

B. Contractor must describe the use and operation of all recommended test equipment in addition to calibration, diagnostic and repair procedures. Tools and test equipment which are commercially available and not specially designed for maintenance of the Contractor-furnished equipment shall not be furnished. The Contractor shall, however, provide a list of the latter equipment to guide CTA in equipping a technician's workshop at the Control Center.

3.05 TRAINING

A. The Contractor shall provide and include in the contract price on-site training for furnished SCADA modifications. Selected CTA project implementation staff and all persons responsible for the SCADA RTU maintenance shall receive training. Additional CTA staff may also wish to attend the courses provided; therefore, Bidder is to submit pricing on a per person basis for these additional persons who may attend.

B. Training must be conducted by experienced personnel, supported by training aids. An adequate number and/or amount of training material shall be provided by the Contractor to each student. The following is considered a minimum:

1. Functional flow charts, overall block diagrams, descriptive material and program source listing for all software, except the operating system and diagnostics.
2. Schematic drawings for each of the hardware components.
3. Assembly drawings for each major hardware element, rack or enclosure.
4. All procedure manuals, specification manuals, and operating manuals.
5. Documents covering full scale maintenance program for the System.

C. Participants shall receive individual copies of technical manuals and pertinent documentation at the time the course is conducted. The courses shall be scheduled so that each person can participate in all courses.

D. Bidder shall provide course outlines (including duration and student pre-requisites) in their proposals. Each course outline should include, in addition to the subject matter, how this course fits into the overall training program; recommended participation; the objective, the standards of evaluation; and any other topics which will enhance the training environment.

APPENDIX - A
SUBSTATION CONTROL/ALARM/TELEMETERING

TABLE - A

CONTROL UNIT NUMBER	AT MASTER STATION	AT RTU								
		CONTROL (INTERPOSING RELAY)			TELMETERING			STATUS LOGIC		CONTROL (Latching RELAY)
	FUNCTION	CLOSE	TRIP	LOCK-OUT	AC VOLT	DC VOLT	AMP	A	A 1	EMERGENCY CLOSE
##	DC FEEDER #503	X	X			X	X	X	X	
##	DC FEEDER #504	X	X			X	X	X	X	
##	DC FEEDER #505	X	X			X	X	X	X	
##	DC FEEDER #506	X	X			X	X	X	X	

STATION SCADA LOGIC/INDICATION

TABLE - B

DC FEEDER BREAKERS

A	A1	INDICATION	DESCRIPTION
0	0	R/G	LOCAL/ALARM
0	1	G	OPEN
1	0	A	LOAD MEASUREMENT
1	1	R	CLOSED

LEGEND
A = AMBER
B = BLUE
G = GREEN
R = RED

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASURMENT

A. The work of SUPERVISORY CONTROL EQUIPMENT will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the work of SUPERVISORY CONTROL EQUIPMENT must be included in the contract lump sum price as shown in the Schedule of Prices for Traction Power Work.

4.03 PAY ITEM ACCOUNT NUMBER

A. Traction Power Work: 340000

END OF SECTION

SECTION 34 21 95

TRACTION POWER DISTRIBUTION SYSTEM TESTING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 Summary

A. This section covers the requirements for field testing of traction power distribution equipment installed along the right-of-way.

B. All traction power equipment furnished and installed under this contract will be subject to the test program described herein.

C. The Contractor will formulate overall test program of the equipment which will include but not be limited to the tests specified in this Section to ensure equipment compliance with the relevant standards, this Specification and satisfactory and reliable performance in intended operation.

D. This section does not cover field testing of substations or substation apparatus but is intended as a functional test prior to energizing wayside equipment such as cable, switches, and contact rail.

1.03 FACTORY TESTS

A. This section does not cover factory testing.

1.04 FIELD TESTS

A. Tests in the field will include but not be limited to:

1. Manufacturer's standard tests
2. Test as per currently applicable NEMA, IEEE and ANSI Standards.
3. Any other tests to ensure satisfactory performance of the traction power equipment.

1.05 TEST REPORTS

A. The Contractor will submit certified copies of test reports for all the tests conducted in field for Authority's approval. Test reports will be submitted to the Authority within seven days after completion of tests. Test reports will contain the characteristics curves, etc. where required for interpretation of results.

1.06 CONDITIONS FOR TESTS

A. General Conditions

Prior to testing of any equipment specified in this Section, all of the following conditions will be fulfilled by the Contractor:

1. All shop drawings of the equipment to be tested have been approved by the Authority.
2. The Contractor will submit a step by step test procedure including pass-fail criteria to the Authority two weeks in advance of the commencement of the test. The Authority reserves the right to add, delete and make necessary changes in the test procedure. The Contractor will arrange to conduct all tests per the Authority's approved procedure.
3. Testing will not commence without an approved test procedure.

B. Witnessing Tests

1. The Authority's personnel and/or their authorized agents will witness testing of all equipment unless a waiver is granted, in which case test reports of equipment for which waiver was granted, will be submitted for review.. Waiver of witnessing tests on equipment will not be construed as a waiver for all remaining equipment either of the same type or different type. Contractor will provide the Authority a minimum of one (1) week notice prior to commencing the test, so the Authority can schedule personnel for witnessing the tests.

C. Responsibility

1. The Contractor will assume full responsibility during the field testing of all equipment and installation provided by him. Should there be any loss or damage to such equipment, materials or the building as result of these tests, the Contractor will be fully responsible for replacing the damaged equipment and repairing the building. Replacement of damaged equipment will include all costs, including but not limited to, transportation of, testing and installation of replacement equipment.

D. Rejection and Retesting

1. Failure of equipment to successfully pass the tests or to meet ratings will be sufficient grounds for rejection of equipment.
2. Any equipment rejected will be retested in presence of the Authority after rectification. If the modifications or changes are such as to affect any of the drawings, diagrams or any other documents submitted and accepted by the

Authority, revised drawings or diagrams will be submitted, showing proposed changes and Authority's approval obtained before changes or modifications are made on the equipment. Modifications or changes which do not warrant revision of any drawing will be furnished to the Authority along with notice of retesting.

3. If it is not possible to rectify rejected equipment, new equipment will be manufactured and the requirements of the drawings and design calculations of the original unit will be applicable for the new unit.

E. Cost of Rectification or New Unit

1. The entire cost of rectification or new unit will be borne by the Contractor including retesting and cost of witnessing retesting.

1.07 SUBMITTALS

A. At a minimum, the following will be submitted for review:

1. Field test procedure.
2. Test equipment specifications.

B. Field test results.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.01 FIELD TESTS

A. General

1. Contractor will perform the field tests on all equipment specified in this Section after installation of the equipment.
2. The work includes furnishing labor, material, test instruments and services necessary to perform required testing and checking of electrical equipment installation.
3. All tests will be successfully completed to show that the installation meets the specification requirements and that the equipment and devices operate as intended, before final acceptance by the Authority.
4. Tests and checkouts will be conducted in accordance with the Authority's approved test procedure specified herein and in National Electrical Code, and applicable Standards and Specifications' of ANSI, NEMA, etc.
5. Contractor will provide properly qualified personnel who will be responsible for supervising, coordinating, and performing all the electrical field testing and checking work and who will maintain a written record of tests conducted.
6. Testing and checkouts will be performed in the presence of the Authority.

7. Contractor will furnish four copies of all tests results to the Authority. Result sheets will include date of test, personnel involved, items tested, type of tests and test data.
8. Any equipment or material damaged due to improper test procedure or test apparatus handling will be replaced or restored to original condition by Contractor at his expense.
9. Safety devices including but not limited to rubber gloves and blankets, screens and barriers, danger signs, padlocks, etc., will be used to protect and warn all personnel in the vicinity of the tests.
10. All test instruments used will have a certified calibration sticker showing last date calibration and expiration date.

B. Field Test Requirements

1. Contractor will formulate a complete Field Test procedure for all equipment to be furnished and installed under this Contract. Test procedure will be comprehensive and will include the required tests as specified in relevant standards of ANSI, NEMA and IEEE, supplementing the Factory Test Procedure.
2. The Contractor will submit the test procedure to the Engineer for review and approval well in advance to the commencement of field tests. Engineer reserves the right to add, delete or make necessary changes in the test procedure. The Contractor will arrange to conduct all the field tests as per the Engineer's approved procedure. Since the Contractor is responsible for the performance and installation of the equipment furnished under this Section, he will, therefore, prior to testing, verify that the installation is proper and in accordance with all applicable installation instructions specified herein.

C. The following tests will be performed.

1. Traction Power Cables:

a. After cable installation, and immediately before the splices are made or terminal lugs applied, the protecting caps or tape will be removed and each length of cable so exposed will be immediately tested with a portable megohm-measuring instrument having a minimum range to 10,000 megohms and a 1,000 volt constant potential generator. These insulation resistance tests will be made to earth ground for surface or underground installation, where ground is a temporary rod electrode driven for connection to the megger instrument. The remote ends of cable (other end from test location) will be open during this test. Splicing and termination of cables will proceed immediately after testing, provided insulation resistance exceeds the following minimum values, which are based on 500' cable length or less, and are adjusted to allow for lower readings that could be caused by high ambient temperature and/or high relative humidity.

b. Above ground installation will use CTA elevated structure for reference.

Cable Size	Minimum Insulation Resistance
1,500 KCMIL	20 meg ohm mile
500 KCMIL	20 meg ohm mile

c. If the insulation resistance is lower than the minimum megohms listed above, the Contractor will report the condition to the Authority for determination of appropriate remedial procedures.

d. After all splices and lugs are applied, but before the connection are made to apparatus, contact rails and other equipment, each continuously connected length of cable will again be tested with the megohm measuring instrument specified above. If the insulation resistance of a wire or cable so measured is less than the permissible megohms of resistance set forth in the following table for cable being tested, the cause of the defect will be determined by the Contractor and corrected to the satisfaction of the Authority and the cost of such remedial work will be borne by the Contractor.

Minimum Insulation Resistance in Megohms to Ground for Range of Cable Length are:

Cable Size	Up to 500 feet	500 feet to 1000 feet	1000 feet to 1500 feet
500 KCMIL	650 Mohm	650 to 325 Mohm	325 to 215 Mohm
1,500 KCMIL	500 Mohm	500 to 250 Mohm	250 to 170 Mohm

e. The Contractor will keep a record of the insulation tests and will forward the required copies to the Authority for examination and approval. See a sample of the test form.

DATE_____
PROJECT NAME_____
FEEDER NUMBER¬ FROM_____LOCATION_____
FROM_____TO_____
CABLE SIZE_____CABLE LENGTH_____
NUMBER OF CONDUCTORS_____INSULATION TYPE_____
MANUFACTURER_____LINE VOLTAGE_____
TEMPERATURE_____HUMIDITY_____
MEGGER TYPE_____SERIAL NUMBER_____
TEST VOLTAGE_____MULTIPLIER_____
REMARKS_____

Where Applicable, All shields must be properly grounded prior to testing

Cable No.	MEGOHMS	MEGOHMS	MEGOHMS
Phase A	Phase B	Phase C	

TEST PERFORMED BY: _____
SIGNATURE DATE

TEST WITNESSED BY: _____
SIGNATURE DATE

D. Hand Operated Switches and Motor operated switches (MOS):

1. Before traction power cables are connected, the following inspections and tests will be made on the switches by the Contractor.

   a. Test insulation resistance to ground employing 1,000 Volt megger with test ground electrode. If insulation resistance is less than 50 megohms, the Contractor will make required corrections to the satisfaction of the Authority without cost to the Authority.
   b. Inspect blade and clip parts of switch for proper alignment, clean and dry contact surfaces. Operate the switch, checking switching action, wipe, and action of quick break mechanism.
   c. Operate all disconnect and sectionalizing switches to ensure positive operation without binding or otherwise mis-operating.
   d. Open, close, latch, unlatch, lock, unlock all cabinet doors to ensure correct operation and clearance.
   e. Inspect switch terminal pads for clean, dry surfaces for electrical connections.
   f. Before connecting traction power cables, the Contractor will make continuity tests to ascertain that the correct traction power cable is in place for connection.
   g. After cables are connected, the Contractor will test the clamping force of bolted electrical connections with an accurate torque wrench. Bolted electrical connections will be tested for the following torques:

      Minimum Torque (Lb-In)

Bolt Size	Hardware not Lubricated	Hardware Lubricated
3/8 inch 16	240	170
1/2 inch -13	480	300
3/4 inch 10	840	720

h. Verify the remote operation of the MOS, after removing power from both sides

E. Contact Rail System:

1. Perform continuity and dielectric tests to prove contact rail is properly connected and insulated.With cables feeding contact rail disconnected, test resistance to ground (elevated structure) using a 1000 volt ohmmeter test set ("Megger"). Minimum resistance will be 300Mohm/ft.
2. Perform continuity test to prove that contact rail is properly connected and that no inadvertent connections exist (such as temporary connections to kick/lap rail etc.)

a. Check that all contact rail, cable connections, rail taps, and other traction power elements are properly set and clear of interference with rail cars and other traffic.
b. Verify that all the gaps are installed as per the drawings.
c. Verify that a minimum of 40 ft gap is maintained at all the section gaps.
d. Verify that contact rail anchors are installed at the required locations as per the standard drawings.
e. Verify that chairs are installed at regular intervals, and maintain the clearance requirements specified in the standard drawings.
f. Verify that all rail taps are installed with clearances as required per the standard drawings and specifications.
g. Verify that the chairs are properly shimmed and a 6.5” height difference is maintained between the top of contact rail to the top of running rail.
h. Verify that the resistance of each welded cable at the point of application will not exceed 10.6 micro-ohms. Perform this test (Ductor test) on 10% of welded cables. Based on the results of the resistance test, the Authority will determine if to reduce or increase sampling
i. Verify that the electrical resistance of finished splice/joints in composite contact rail measured 36 inches across the joint with the center of the joint at the center of the measurement be equal or less than the electrical resistance of 36 inches of non-jointed composite contact rail. Perform this test (Ductor test) on 10% of splice joints. Based on the results of the resistance test, the Authority will determine if to reduce or increase sampling

F. Negative Return

1. Verify that all the negative return bonds including rail to rail bonds, rail to structure bonds, impedance bonds, cross bonds, auxiliary negative bonds, bypass cables, substation negative return bonds, etc are installed as per the drawings and the Authority’s standards.
2. Each weld will be mechanically tested by striking the weld with a mallet. In addition, verify that the resistance of each welded cable at the point of application will not exceed 10.6 micro-ohms. Perform this test (Ductor test) on 10% of welded cables. Based on the results of the resistance test, the Authority will determine if to reduce or increase sampling
3. Verify that the electrical resistance of finished splice/joints in ANR measured 36 inches across the joint with the center of the joint at the center of the

measurement be equal or less than the electrical resistance of 36 inches of non-jointed rail. Perform this test (Ductor test) on 10% of splice joints. Based on the results of the resistance test, the Authority will determine if to reduce or increase sampling

4. Bolted electrical connections of the impedance bond and negative bus will be tested using a torque wrench as per Section 3.01 D.1.g.

G. Rail Heaters

1. After all wires and cables are in place and connected to devices and equipment, test system for shorts, grounds or other resistances.
2. Perform functional and operational tests of all equipment. Test and verify local and remote operation and control of contact rail heating system.

H. Section Proving test

1. Upon completion of the installation, disconnect and completely remove any temporary work prior to commencement of testing. Perform section proving tests for the contact rail, cabling, switches, and return system for proper sectionalization and insulation.

I. Section proving tests should include testing of sections to ensure there are no inadvertent or improper connections between sections of contact rail especially at section breaks.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASURMENT

A. The work of TRACTION POWER DISTRIBUTION SYSTEM TESTING will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the work of TRACTION POWER DISTRIBUTION SYSTEM TESTING must be included in the contract lump sum price as shown in the Schedule of Prices for Traction Power Work.

4.03 PAY ITEM ACCOUNT NUMBER

A. Traction Power Work: 340000

END OF SECTION

SECTION 34 24 19

CONTACT RAIL SYSTEM

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 DESCRIPTION

A. The Contact Rail System consists of composite contact rail, support insulators, anchors, bonds, cables, disconnect switches, jumper system, and other ancillary devices required to complete the contact rail system and deliver power to the trains.

B. The contact rail layout is coordinated with the track layout to ensure that operating requirements are met. Wherever possible, the contact rail will be located opposite from station platforms and emergency walkways.

C. The contact rail system is designed to the track alignment and shall be coordinated with the car clearance envelope.

D. Any temporary cable work required to maintain service during and throughout the construction period is described in Paragraph 3.01.G of this specification. All temporary work shall be installed and allow for normal train operations and removed prior to final acceptance. Note: The work required for moving between temporary phases of work to the final configuration including removal of all temporary work will be included in this Contract as part of completing the work.

E. The completed contact rail system shall perform its intended function of supplying electrical current to trains without injurious effect to itself or train current collectors including arcing from improperly installed contact rail. It shall provide a smooth and level interface between itself and collectors in a constant relation to the running rail in horizontal and vertical planes.

F. The completed end approach inclines shall exhibit no undue lifting and their base shall be in the same plane as the completed section of contact rail to which they are attached. The inclined plane shall be such that there will be smooth gradual transition of contact rail shoes onto the contact rail.

1.03 SUBMITTALS

A. Submit shop drawings, product data, test procedures, as-built drawings, and samples of contact rail, insulator chairs, shims, contact rail anchors, splice bolts (for temporary installation of contact rail and end approaches) for CTA approval before purchase.

PART 2 - PRODUCTS

2.01 Contact Rail

A. Type

1. The contact rail shall be replaced with new contact rail and contact rail inclines fabricated from 85 lb. ASCE steel base rail, fishplates and 85 lb. ASCE steel base rail clad with aluminum extrusions on each side of the web, including aluminum splice plates, compression fasteners and steel fishplate assemblies for use as contact rail for rapid transit trackwork as outlined in the contract specifications.
2. At least five (5) years of documented and successful in track experience is required.

B. End Approach Inclines

1. Contact rail inclines shall be fabricated from the 85 lb. ASCE base rail and as shown on the Contract Drawings.
2. Cutting and welding of the contact rail inclines shall be in accordance with AWS D15.2 Recommended Practices for the Welding of Rails and Related Rail Components for Use by Rail Vehicles and shall be performed by certified welders who have been requalified within twelve months of performing this work. The Contractor shall submit the welder certificates and welding procedures to the Authority for approval prior to commencing fabrication work.
3. The joint ends of the single inclines shall be drilled as indicated on the Contract Drawings.

C. Contact Rail Anchors

1. Provide insulated anchors to restrain the contact rail in the longitudinal direction from expansion and contraction also to prevent the longitudinal forces from being transmitted to the insulators.
2. Provide anchor system that allows full stress to develop in the anchors without deformation or pull-out of threaded rods.
3. The Contractor shall provide new angle brackets per Contract Drawings. The existing brackets shall be removed and scrapped to the benefit of the Contractor.
4. Remove the existing anchors and provide new anchors at midpoint of the section length. The locations of the anchors are not shown on the drawings.

D. Splice/Joint Bars

1. An aluminum splice joint assembly shall be used to join sections of aluminum clad contact rail. The aluminum splice joint assembly shall consist of two 6101-T6 aluminum alloy extrusions, 24 inches long, and four 7/8 diameter compression fasteners with necessary flanged collars.
2. The steel splice joint assembly shall consist of two steel fish plates, and four track bolts, washers, and nuts.
3. Install the splice bars to avoid interference with the operation of contact rail shoes or ice scrapers in use by CTA.

E. Contact Rail Insulators

1. The Contractor shall provide insulators in accordance with the plans to support the contact rail. Use the table shown on STP-101 to determine proper height of insulator based on running rail and contact rail present in the area. Only use insulator heights that correspond to contact and running rails in that area, no custom height insulators are allowed

F. Contact Rail Insulator Shims

1. Shims for increasing the height of the insulator will be allowed for making small adjustments in height of the insulator.
2. The thickness of shims shall be 1/8", ¼" and 3/8" as required, and conform to the size and shape of the insulator base and holes.
3. The shims shall be made from nylon, or marine-grade wolmanized wood.

G. Electrical Properties

1. The assembled composite contact rail shall be capable of carrying a current of 5,000 amperes on a continuous basis without exceeding a temperature rise of 40ºC above ambient temperature in still air.

H. Contact Rail Taps

1. Each cable to rail connection shall be made with a contact rail tap assembly. Contact rail tap assemblies shall not be located within two feet of a contact rail joint or contact rail insulator chair. The number and length of the 300 MCM bootleg bonds shall be as shown on the Contract Drawings. The terminal ends of the bootleg bonds are designed to hook over the flange of the contact rail and so hold the bonds in position during welding. The terminal lug shall be soldered to the bonds such that the bonds will not be twisted when applied to the rail.
2. When it is indicated on the drawings that a contact rail tap is to remain in place, it shall be understood that the portion of the rail tap connected to the old rail shall be replaced in its entirety. For example, the bond(s), bronze bolt(s), and lug(s) to contact rail shall be replaced, while the existing cables(s) to lug(s) connection may remain in place, as indicated on the Contract Drawings.

I. Negative Bonding

1. The Contractor shall not compromise negative bonding that provides signal return circuit integrity.
2. The negative return system shall ensure that every section of track has at least one running rail used for return current.
3. The Contractor shall install 2 exothermic bond connections across running rail joints and under the joint bars for each location determined to be a negative return path as shown on contract drawings.STP-418.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Contact Rail Insulators

1. Provide contact rail support fiberglass insulators that are uniform and similar to the existing insulators. The insulators shall be as shown on the plans. Existing insulators shall be disposed of.
2. Contractor shall apply for and receive approval from CTA of final proposed location of all contact rail support insulators including locations of end approach inclines to ensure final insulator layout conforms to CTA standards, as shown on the Contract Drawings, before commencing work.
3. Insulators when installed shall provide 6 1/2", plus 0" or minus 1/8" vertical distance between the plane made by the top of the running rails and the top of contact rail. Use a gauge bar template to ensure both are in the same plane. Should a particular location cause the insulator to be too low, shimming will be allowed. The maximum shimming height is 1/2 inch and the maximum number of shims in any one location is two. Insulators requiring shimming greater than ½" need to first be approved by CTA, and then proceed at their direction. Horizontal distance between the gauge face of the running rail and the centerline of the contact rail shall be 1'-8 1/8", plus or minus 1/8 of an inch.
4. Contractor shall utilize a gauge bar template which lays across both running rails for installing insulators to ensure the correct and uniform height and alignment to the running rail. Design of gauge shall be approved by the CTA.
5. Locate insulators no more than eight feet (six feet on curves) apart in accordance with contract drawings.

B. Contact Rail

1. Contact rail shall be installed to line and grade, with relationship to track plane, as indicated herein and shown on contract drawings.. The contact rail shall rest evenly and uniformly on all insulators.
2. For curves of 2,500 foot radius or less, the contact rail shall be pre-curved. After curving, the contact rail shall be free of kinks, twists, nicks, or other undesirable conditions.
3. When two pieces of contact rail are joined, the outer surface of the aluminum extrusions shall be first cleaned of oxide, and then immediately coated with an approved oxidation inhibiting compound. Similarly, the inside surface of the splice/joint bars shall be cleaned of oxide and immediately coated with

the oxidation inhibiting compound. The joint between the rails shall be butted and the splice/joint bars and compression bolts applied.

4. Once temporary connections in contact rail are no longer required replace mechanical nuts, bolts and washers with Huck pins and collars for final configuration. Use 4 (four) Huck pins for each joint/splice bar assembly. Contractor needs to re-test joint resistance (see item 9 below) and ensure surfaces are prepared properly before and after Huck bolts are installed.
5. At every joint if required, lightly grind the rails to ensure even surfaces between the two rails or between the rail and end approach incline.
6. Once a section of contact rail is complete (end approach incline to end approach incline) anchor it at the midpoint of the run. Anchors shall be installed on the field side of the contact rail as shown on contract drawings as required for the particular situation. If the Contractor is unable to install the anchor as shown on the drawing, then the Contractor shall install the anchor as directed by the CTA.
7. End approach inclines shall be attached to each end of a contact rail section (see Contract Drawings for proper size end approach for the particular contact rail section). End approach inclines shall be installed to line and grade with relationship to the running rail.
8. End approach inclines shall rest uniformly on all insulators. When connected to complete a section of the contact rail, the end approaches shall not lift off from the insulators. The base shall be on the same plane as the contact rail to which it is connected.
9. Electrical resistance of finished splice/joints in composite contact rail measured 36 inches across the joint with the center of the joint at the center of the measurement shall be tested to be equal or less than the electrical resistance of 36 inches of non-jointed composite contact rail. The test shall be made in the presence of CTA or their approved representative.
10. Should any splice/joint fail this test then the Contractor shall replace the splice/joint with a new installation. If the splice/joint fails a second time the Contractor shall notify CTA and proceed as CTA directs. If this situation can not be resolved then the Contractor may have to install special rail bonds across the joint as directed by CTA, at no additional cost.
11. Assemble and align the contact rail sections, in both horizontal and vertical planes, so that when a 6 foot level is placed on the top of the rail head, no deviation greater than 1/64th of an inch is observed between the ends of the level.
12. The splice/joint should result in a minimum of electrical resistance across the interface for the transfer of electric current. The splice/joint bars shall be predrilled to match the two-drilled holes in the end of the composite contact rail so that when two pieces of rail are butted together, the splice/joint bars can be applied with Huck bolts without field alterations of any kind.
13. The assembly shall butt tightly together allowing no more than 1/8 inch gap between rail sections. All completed contact rails and end approach inclines shall be smooth on heads and bases, straight in line and surface, without twists, kinks, waves or defects of any kind.

C. Cable Connections to Contact Rail

1. Contact rail tap cables from either disconnect switches, gap jumpers, auxiliary, or parallel cables shall be welded to the contact rail as shown on

contract drawings. Contractor shall submit welding details for approval by CTA.

2. The surface of rails where cables(s) are to be connected shall be ground clean with a vitrified grinding wheel. After grinding the surface shall be cleaned with a non-toxic solvent to remove all traces of dirt and grease. After the surface has been ground and cleaned the surface shall be heated to drive out any moisture. The cable shall be welded to the rail in such a manner as to ensure a thorough mechanical and electrical connection. In the event the weld is not made immediately after grinding the surface it shall be coated with a rust prevention material. Follow the cleaning procedure specified above before making the weld.
3. Before commencing work of welding the Contractor, at his expense, shall require each welder to weld, in the field, under conditions similar to those of the actual work area, not less than three complete rail connections and as many more as required by CTA to determine the welds are being made satisfactorily, The welds will be subject to inspection and test by CTA and their approval as to method and quality of workmanship will depend on the results of these inspections and tests. Final approval of welders shall be by CTA.
4. Each rail connection shall be thoroughly welded to the rail and to reduce the possibly of these welds breaking in service the CTA will require a test of each weld by hammer (weight to be determined by the size of cable and weld) furnished by Contractor, or in a manner which in the opinion of CTA is reasonable.
5. Any bond, weld, or connection which in the opinion of the CTA is found to be defective, shall be removed and a new bond, weld, or connection shall be installed at the expense of the Contractor.
6. The resistance of each welded cable at the point of application shall not exceed 10.6 micro-ohms. Each weld will be tested and results recorded in a manner approved by CTA. Any weld which in the opinion of CTA does not meet this resistance level shall be removed and reconnected at the expense of the Contractor.
7. Cables shall not be welded to an end approach incline under any circumstances.
8. Cables shall be installed with respect to insulators as shown on contract drawings.
9. The finished cable installation and connection to the contact rail shall have sufficient clearance (minimum of 6 inches) so that the cable(s) do not chafe or encroach on the contact shoe or any other fixed or movable structure. Stub-ups at switch locations should extend up to the bottom of the switch box. The stub-ups should ensure that the cable is completely protected all the way into the switch enclosure.

D. Contact Rail Gaps and Sectionalization

1. The contact rail shall be installed in sections of no more than 2,000 feet. Each section shall terminate with an end approach incline. Each section shall be anchored at a point within 2 feet of its midpoint.
2. Non-sectionalizing contact rail gaps shall not exceed 30 feet (unless approved by CTA) to ensure that one shoe of the car is always in contact with the contact rail at all times. However, power section breaks shall be 40 feet

minimum to ensure that the car can not bridge two isolated sections of contact rail. All gaps shall be in accordance with CTA Standards.

E. Transition Contact Rail

1. The Contractor should make every effort to install complete sections of contact rail during each work window since the contact rail lengths are relatively short. Effort should be made to only install complete sections of contact rail and avoid making temporary ends and temporary connections.
2. If the Contractor is unable to install a complete section of contact rail, temporary end approach inclines will need to be installed although no gaps shall exceed 30 feet.
3. Two temporary 1,500 kcmil jumper cables shall be run between gaps to ensure electrical continuity if situation happens outside of by-pass cable area. The cables shall be welded to each rail in a manner approved by CTA. Cables shall be temporarily protected and fastened to the invert to prevent interference with vehicles, contact rail shoes or personnel.
4. Costs for temporary end approach inclines and temporary cables, if required, shall not be paid separately, but shall be in the Contractor's overall costs of contact rail installation.
5. This temporary type of installation should not persist for more than seven calendar days and typically be corrected/completed the next day if it can not be avoided altogether.

F. Contact Rail Anchors

1. Contact rail anchors shall be installed on each continuous length of installed contact rail and located midway between the two inclines as shown on contract drawings.
2. The steel angles attached to the base of the contact rail and to the timber guard shall be parallel to the contact rail.
3. Angles to be installed on the contact rails shall be welded to the rail by the electric arc welding process. Welding rods used shall conform to American Welding Society Standard AWS A-5.l, latest edition, "Specification for Mild Steel Covered Arc Welding Electrodes", Electrode Classification No. E601Dr E7018.
4. Only properly qualified and certified welders shall be employed by the Contractor for the welding attachment of the angle. The Engineer shall make any tests which in his opinion may be necessary to locate defective workmanship, and the Contractor shall replace without additional compensation, including material so ordered, all defective welding, which may be found, or which may result from tests, during the progress of the work and before acceptance by the Authority.
5. Before welding, all surfaces shall be thoroughly cleaned of scale, grease, rust, paint and other substances by approved methods. The weld between each angle and the steel rail shall be built up the electric arc welding process.
6. Angles to be installed on the timber guard shall be fastened with galvanized bolts and nuts as shown on contract drawings.

G. Temporary Work

1. Provide work necessary to relocate temporary cabling, contact rails, related equipment and materials during construction work. This may involve several movements of these items as construction progresses.
2. Provide any required negative bonding to ensure integrity of the negative return circuit during construction work.
3. Disconnected cable that is to be reused shall be de-energized, secured to the structure and protected from water intrusion.

3.02 Testing

A. Upon completion of the installation, disconnect and completely remove any temporary work prior to commencement of testing. Perform section proving tests for the contact rail, cabling, switches, and return system for proper sectionalization and insulation. Submit test procedure(s) in accordance with Division 1 section – Submittals, for approval by CTA. Test procedures must be approved four weeks prior to performing any tests.

1. Section proving tests should include testing of sections to ensure there are no inadvertent or improper connections between sections of contact rail especially at section breaks.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASURMENT

A. The work of CONTACT RAIL SYSTEM will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the work of CONTACT RAIL SYSTEM must be included in the contract lump sum price as shown in the Schedule of Prices for Traction Power Work.

4.03 PAY ITEM ACCOUNT NUMBER

A. Traction Power Work: 340000

END OF SECTION

SECTION 34 24 22

CONTACT RAIL INSULATOR CHAIR - FIBERGLASS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. The Contractor shall furnish and install all contact rail insulator chairs as shown on the Contract Drawings and/or specified, including the furnishing of all collateral material.

B. This work includes the assembly of the fiberglass contact rail insulator chairs which include the Fiberglass Reinforced Polyester (FRP) block design and the installation of these chairs on new, relocated or existing chair ties.

C. The contact rail insulator chairs specified herein are used to support various sizes of steel contact rails, as well as the newer aluminum composite contact rail.

1.03 REFERENCES

A. ANSI C29.1 - Electrical Power Insulators - Test Methods.

B. ASTM A47 - Standard Specification for Ferritic Malleable Iron Castings.

C. ASTM D149 - Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.

D. ASTM D150 - Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.

E. ASTM D256 - Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics.

F. ASTM D495 - Standard Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation.

G. ASTM D570 - Standard Test Method for Water Absorption of Plastics.

H. ASTM D638 - Standard Test Method for Tensile Properties of Plastics.

I. ASTM D648 - Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position.

J. ASTM D695 - Standard Test Method for Compressive Properties of Rigid Plastics.

K. ASTM D790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

L. ASTM D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

M. ASTM D955 - Standard Test Method of Measuring Shrinkage from Mold Dimensions of Thermoplastics.

N. ASTM D2303 - Standard Test Methods for Liquid-Contaminant, Inclined-Plane Tracking and Erosion of Insulating Materials.

O. ASTM E162 - Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source.

P. ASTM E662 - Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials.

Q. ASTM E800 - Standard Guide for Measurement of Gases Present or Generated During Fires.

R. NFPA 258-T - Recommended Practice for Determining Smoke Generation of Solid Materials.

S. UL 94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

T. UL 746C - Standard for Polymeric Materials - Use in Electrical Equipment Evaluations.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Castings:

1. The castings shall be made from ASTM A47, Grade 32510, Ferritic Malleable Iron.
2. Tooling and molds shall be fabricated to produce castings that meet the dimensions shown for the applicable rail size called for within the Contract Documents. All tooling and molds shall be the responsibility of the Contractor.
3. Castings shall be thoroughly annealed. If a casting is rejected for insufficient annealing, it may be re-annealed only once.
4. Surface of castings shall be visually inspected by the Contractor, particularly in critical areas. Castings shall have smooth surfaces, free of injurious defects such as burrs and sharp edges, as well as other surface defects such as cracks, hot tears, adhering sand and/or scale, cold shuts, and gas holes. No repairing, plugging, or welding shall be permitted on the castings without written approval by the CTA.

B. Insulator Blocks:

1. The insulator blocks shall be molded to the dimensional requirements indicated on the Contract Drawings from a fiberglass-reinforced polyester material (FRP).
2. Insulator blocks shall be rated for 650 VDC (nominal) with voltage spikes to 3500 volts (10 to 25 millisecond duration).
3. The FRP insulator block surface shall be resin rich, smooth and uniform in appearance. Materials used shall be resistant to abrasion, marking, scratching, moisture, sunlight and be unaffected by weather or sudden changes in temperature over the atmospheric climatic range for the Midwestern United States.
4. The color of the insulator block shall be light gray, No. 70 conforming to ANSI Z55.1. The color shall be uniformly dispersed throughout the material with minimum variance between material batch lots.
5. The insulator block shall be designed to withstand temperatures of –32 degrees Fahrenheit to +120 degrees Fahrenheit, without undergoing any permanent thermal, electrical or structural deformation.
6. Each FRP insulator block shall be permanently and legibly marked with identification of the manufacturer and year made.

2.02 MATERIAL PHYSICAL AND ELECTRICAL PROPERTIES

A. All reference standards herein referred to shall be the latest revision of that particular standard at the time of Invitation For Bid.

B. The FRP insulator block material shall meet the following requirements:

PROPERTIES	TEST METHOD	VALUE
Flexural Strength (psi)	ASTM D790	20,000
Tensile Strength (psi)	ASTM D638	8,000
Izod Impact Strength (ft.lbs/in)	ASTM D256	15
Compressive Strength (psi)	ASTM D695	18,000
Water Absorption (percent gain)	ASTM D570	0.2
Heat Distortion Temp (degrees Celsius 264 psi)	ASTM D648	180
Specific Gravity (min.)	ASTM D792	1.80
Shrinkage, Compression Molding (in/in)	ASTM D955	0.001 to 0.004
Arc Resistance (sec.)	ASTM D495	80
Dielectric Strength-(v/mil)	ASTM D149	380
Dissipation Factor (min.)	ASTM D150	0.016
Dielectric Constant	ASTM D150	5.0
Tracking Strength – Inclined Plane (Minutes at 2500 v)	ASTM D2303	600

PROPERTIES	TEST METHOD	VALUE
Flame Resistance – Ignition time (sec.)	UL 94	V-0 min 10
Flame Propagation Index (I_s)	ASTM E162	60 Max
Smoke Generation Specific Optical	ASTM E662	
Density (D_s) Start of Test @ 90 Seconds Start of Test at 4 Minutes	NFPA 258-T	25 50
Smoke Generation - Chlorine Content (parts per million)	ASTM E800/ DDC AD 297457 (Type MAI-60)	10
Smoke Toxicity		
Gases (parts per million)		
Hydrogen Chloride (HCl)		10
Hydrogen Bromide		10
(HBrHydrogen Cyanide (HCN)		10
Hydrogen Sulfide (H_2s)		10
Vinyl Chloride (C_2H_3 CI)		10
Ammonia (NH_3)		500
Aldehydes		30
Oxides of Nitrogen		100
Carbon Dioxide (CO_2)		10,000
Carbon Monoxide (CO)		1,000
Weatherability (100 hours of Xenon-arc Weahterometer Conditioning)	UL 746C	f2

C. The Castings shall meet the following minimum value requirements:

PROPERTIES	TEST METHOD	VALUE
Tensile Strength (ksi)	ASTM A47	50
Yield Strength (ksi)	ASTM A47	32.5
Elongation in 2 inches min. (percent)	ASTM A47	10

2.03 TESTING AND ACCEPTANCE

A. Testing:

1. A lot shall be defined as 100 to 500 pieces. A minimum of 1 percent of each lot shall be tested.
2. An electrical resistance test shall be made on 1 percent of each lot to determine the insulation resistance after 72 hours of immersion in water at room temperature, approximately 22 degrees Celsius. After all surfaces have been carefully dried, each insulator block shall show a resistance of not less than 8 megohms when measured by a 1000 VDC megohm meter. For this test, good contact to the insulator block shall be provided by the use of wet clay pads on both the top and bottom surfaces of the insulator block.
3. The electrical resistance test specified in paragraph 2 above shall conform to ANSI C29.1. The FRP insulator blocks shall have a dry withstanding test voltage of 30 kV, 60 Hz for 1 minute and a wet withstanding voltage of 20 kV, 60 Hz for 10 seconds.
4. Castings - As specified in ASTM A47, the Contractor shall cast specimens for testing per the dimensions shown in Figure 1 (or alternate Figures 2&3) of ASTM A47. The specimens shall be cast from a representative ladle of iron from each batch-melted heat, or in continuous melting, from each 4 hour pour period during which the castings were poured. Test specimens shall be subjected to the testing specified in ASTM A47 and shall meet all requirements specified therein.
5. Compression Test: A minimum of 1 percent from each lot of insulator blocks shall be selected at random for compression load testing:

    a. Each insulator block under test shall be supported on a flat base and have a load applied to the top along the vertical axis of the insulator. The load shall be distributed evenly over the entire top surface. The

insulator block shall sustain a minimum compression load of 25,000 pounds.

B. Test Acceptance Criteria:

1. All castings and finished insulator blocks shall pass the testing requirements noted under this Section and shall also be dimensionally inspected.
2. Failing to meet the testing and/or dimensional requirements will be just cause to reject the entire lot of insulators. Failure is defined as the first visible crack.
3. Prior to acceptance of material by the CTA, the Contractor shall submit to the Authority for approval 5 copies of a notarized certified test report from a recognized independent testing laboratory (approved by CTA) stating that the castings and/or fiberglass blocks being supplied have been manufactured and tested in accordance with this Specification. Values indicated in the reports shall be in English Units. Metric units when included, shall be shown in brackets.
4. CTA reserves the right to inspect the casting production facility, and witness testing called for in this Specification, prior to shipment. Contractor shall notify CTA in writing 3 weeks prior to actual testing start. CTA inspector may place a designated mark on which castings that will be tested as they are inspected.
5. The cost for testing and any incidental costs required for certification thereof shall be the responsibility of the Contractor.

PART 3 - EXECUTION

3.01 INSTALLATION OF CONTACT RAIL INSULATOR CHAIRS

A. Each tie on which the insulator chairs are to be installed must be measured for correct positioning of contact rail. The Contractor shall furnish approved measuring devices or templates, approved for use by CTA, which shall be used in measuring the vertical distance from the top of running rail to the top of contact rail and the horizontal distance from the gauge line of running rail to the centerline of contact rail. To correct variation in such horizontal and vertical distances, the ties shall be adzed or creosoted maple shims utilized. Maximum shim height shall not exceed 1/4 inch.

1. Each insulator chair shall be securely fastened to the tie with four 1/2 inch by 4 inch lag screws as shown on the Contract Drawings. Chair lag screws shall not be located under the contact rail and shall be predrilled and screwed (not driven) into the tie. All predrilled holes and adzed surfaces of ties shall be thoroughly saturated with approved creosote oil provided by the Contractor prior to chair installation. The Contractor shall not reuse the holes left after the removal of existing chair.
2. Contact rail insulator chairs shall be spaced a maximum of 8 feet apart on tangent track, and 6 feet apart on curves. An 18 inch minimum clearance

shall be maintained between contact rail chairs and either side of contact rail power tap assembly. In addition, a contact rail chair shall be installed for each incline within the chair support zone as indicated on the Drawings.

3. The Contractor shall install new contact rail chairs on existing chair ties unless physical tie condition prohibits said usage. If this condition exists, and has been verified by CTA Inspector, Contractor can:

   a. Offset existing non-hook bolted tie for use as chair tie.
   b. If existing non-hook bolted tie cannot be offset to meet installation criteria noted in this Section, the Contractor shall install new 6 inch by 8 inch by 8 foot-0 inch chair tie.
   c. Installation and/or offsetting of chair ties shall be as indicated on the Contract Drawings.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASURMENT

A. The work of CONTACT RAIL INSULATOR CHAIR - FIBERGLASS will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the work of CONTACT RAIL INSULATOR CHAIR - FIBERGLASS must be included in the contract lump sum price as shown in the Schedule of Prices for Traction Power Work.

4.03 PAY ITEM ACCOUNT NUMBER

A. Traction Power Work: 340000

END OF SECTION

SECTION 34 24 23

CONTACT RAIL BONDING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This section specifies the requirements for the furnishing and installing of all contact rail bonding.

B. The work under this section includes furnishing all labor, tools, equipment and incidentals necessary to install the contact rail bonding.

1.03 RELATED WORK

A. CONTACT RAIL BONDING specified to be furnished and installed herein have related work in various other sections including, but not limited to:

1. Section 342161 "General Provisions Traction Power"
2. Section 342420 "Contact Rail"

PART 2 - PRODUCTS

2.01 Contact Rail Bonding

A. The Contractor shall furnish and install all contact rail bonding as shown on the Contract Drawings and/or specified, including the furnishing of all collateral material.

B. This work includes the installation and welding of contact rail joint bonds and the installation and welding of contact rail tap assembly boot leg bonds.

C. Each base contact rail joint shall be bonded with 500 MCM AAE bond, as shown on the Contract Drawings or as specified herein.

D. Each structure field designated by the CTA shall be bonded with 300 MCM - 20 inch Type PBAT2 bonds as shown on the Contract Drawings.

PART 3 - EXECUTION

3.01 GENERAL

A. Each cable to rail connection shall be made with a contact rail tap assembly. Contact rail assemblies shall not be located within two (2) feet of a contact rail joint or contact rail insulator chair. Number and length of the 300 MCM boot leg bonds shall be as shown on the Contract Drawings. The terminal ends of the boot leg bonds are designed to hook over the flanges of the contact rail and so hold the bonds in position during welding. The terminal lug shall be soldered to the bonds such that the bonds will not be twisted when applied to the rail.

B. When it is indicated on the drawings that a contact rail tap is to remain in place, it shall be understood that the portion of the rail tap connected to the old rail shall be replaced in its entirety. For example, the bond(s) and lug(s) to contact rail shall be replaced, while the existing cable(s) to lug(s) connection may remain in place, as indicated on the Contract Drawings.

C. Each bond shall be welded to the rail by the electric welding process. Welding rods used shall conform to American Welding Society Standard AWS A-5.1, latest edition, "Specification for Mild Steel Covered Arc Welding Electrodes," Electrode Classification No. E6012.

D. Only properly qualified and licensed welders shall be employed by the Contractor for the welding attachment of the bonds. The Engineer shall make any test which in his opinion may be necessary to locate defective workmanship, and the Contractor shall replace without additional compensation, including material if so ordered, all defective welding, damaged or defective bonding which may be found, or which may result from tests, during the progress of the work and before acceptance by the Authority.

E. Before welding, all surfaces shall be thoroughly cleaned of scale, grease, rust, paint and other substances by approved methods. The weld between each bond terminal and the steel rail shall be built up by the electric arc welding process until every portion of the welded joint has a cross section area greater than that of the bonding cable.

F. It shall be the Contractor's responsibility to insure that each contact rail tap is free to move with the linear thermal expansion and contraction of the contact rail. In cases where existing ties may interfere with this movement, the Contractor shall shorten these ties only in the area from gauge side of the contact rail to the field side of adjacent wood guard rail.

G. The Contractor shall install structure to structure bevels as per the Contract Documents.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASURMENT

A. The work of CONTACT RAIL BONDING will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the work of CONTACT RAIL BONDING must be included in the contract lump sum price as shown in the Schedule of Prices for Traction Power Work.

4.03 PAY ITEM ACCOUNT NUMBER

A. Traction Power Work: 340000

END OF SECTION

SECTION 34 42 00

SIGNAL CONSTRUCTION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section specifies work necessary to protect and maintain the signal system during station construction, including the following areas:

1. California Interlocking
2. Paulina Interlocking

B. Section includes:

1. Description of signal system work area.
2. Detailed description of Work necessary to protect/relocate the signal system during construction of the Cermak Station.
3. Requirements for qualifications of personnel.

1.03 RELATED WORK

A. Signal Construction specified to be furnished and installed herein have related work in various other sections, including, but not limited to:

1. Section 34 21 46 – Traction Power Lugs
2. Section 34 42 03 – Equipment Removal
3. Section 34 42 04 – Signal System Drawing Requirements
4. Section 34 42 09 – Signal Abbreviations and Definitions
5. Section 34 42 20 – Audio Frequency Track Circuits
6. Section 34 42 23 – Impedance Bond Layouts
7. Section 34 42 25 – Rail Connections and Running Rail Bonding

8. Section 34 42 38 – Miscellaneous Components and Products
9. Section 34 42 40 – External Cable
10. Section 34 42 41 – Internal Wire And Cable
11. Section 34 42 62 – Junction Boxes
12. Section 34 42 76 – Grounding Equipment
13. Section 34 42 82 – Control Panel Modifications
14. Section 34 42 90 – Technical Support
15. Section 34 42 91 – Signal System Tests
16. Section 26 05 00 – Raceways and Boxes
17. Section 26 10 00 – Basic Electrical Materials and Methods

1.04 REFERENCES

A. Technical Abbreviations and Definitions.

1. TWPR-twisted pair

B. Publications.

1. None.

C. Reference Standards.

1. American Railway Engineering and Maintenance-of-Way Association (AREMA)
    a. AREMA Manual for Railway Engineering (MRE)
2. American Railway Engineering and Maintenance-of-Way Association (AREMA)
    a. AREMA Communications & Signals Manual of Recommended Practices (C&S Manual)
3. American Railway Engineering and Maintenance-of-Way Association (AREMA)
    a. AREMA Portfolio of Track Work Plans
4. City of Chicago
    a. Municipal Code of Chicago, Title 18 Building Infrastructure, Chapter 18-27, Chicago Electrical Code

5. National Fire Protection Association (NFPA)
    a. NFPA 70, National Electrical Code
6. Federal Railroad Administration (FRA)
    a. FRA Rules, Standards and Instructions for Railroad Signal Systems, Part 236.

1.05 QUALITY ASSURANCE

A. Required Qualified Personnel:
    1. Signal Engineer.
    2. Electrician(s).

B. Qualifications
    1. Personnel shall be qualified to install, reinstall, adjust and test reconnected signal equipment.
    2. Personnel shall be experienced in processors, Harmon and AF-800C audio frequency track circuits, and audio frequency modules.
    3. Only persons qualified with specific training and experience in adjustment equipment will be approved.
    4. Proposed personnel are subject to approval by Authority.

1.06 SUBMITTALS

A. Submit the following in accordance with Section 01 33 00, Submittals, for review by CDOT and CTA:
    1. Process Plans:
        a. Provide process plans according to the requirements of Division One of the Contract Documents.
        b. The process plans shall include temporary and permanent work related to the signal system.
    2. Qualifications:
        a. Names and documentation of experience for each person proposed to perform adjustment and testing of signal system.
        b. Names of each person proposed for each work period when testing of signal system or adjusting of audio frequency equipment is

required.

3. Design, Fabrication and Connection Drawings for Equipment Platforms:
   a. Provide detailed plans that have been checked sealed and stamped by a licensed Structural Engineer current with the state of Illinois.

4. Miscellaneous:
   a. All other submittals as described in the Technical Specifications.

PART 2 - PRODUCTS

2.01 COMPONENTS

A. Audio frequency track circuit and cab signal speed command loop equipment:
   1. Acceptable Manufacturer/Product: GE (Harmon)
   2. Acceptable Manufacturer/Product: Hitachi (AF-800C)

B. Impedance and receive point (RJ's) bonds:
   1. Acceptable Manufacturer: GE (Harmon)
   2. Acceptable Manufacturer: Hitachi (AF-800C)

C. Junction Boxes

PART 3 - EXECUTION

3.01 INSTALLATION

A. General requirements:
   1. Protect all existing CTA assets, including those that are being removed and returned to the CTA.
   2. Workmanship shall be in compliance with AREMA C&S Manual, NFPA70, Chicago Electrical Code, Contract Drawings and Contract Specifications.

3.02 PROJECT WIDE REMOVAL WORK

A. Wayside signal equipment that interferes with or will be relocated in conjunction with station construction and station demolition::

1. Equipment includes but is not limited to the following:

a. Impedance bonds and associated platforms.

b. Junction boxes and associated platforms.

c. Other components as shown on Contract Drawings.

B. Express and local signal cables
C. Messenger cable and brackets

3.03 PROJECT WIDE RENEWAL WORK

A. Furnish and install the following new material, equipment, and systems as indicated on Contract Drawings and in accordance with referenced Contract Specifications:

1. Cables and associated materials, in accordance with Section 34 42 40, External Cables:

a. Signal cables (Line Circuit and Audio Frequency Train Detection cables).
b. Messenger, messenger wire hangers, supports, brackets, dead-ends, and associated hardware.
c. GRS rigid conduit system, including conduit, hangers, supports, brackets, expansion couplers, fittings and associated hardware through Damen Station underneath the Platform Area , coordinated with station electrical conduit installation and in accordance with Section 26 05 00, Raceways and Boxes, and Section 26 10 0, Basic Electrical Materials and Methods, Local cables to wayside signal equipment.
e. Cable for station annunciators
f. Temporary Signal cables as required to maintain signal system operation during station demolition and to facilitate station construction staging.

2. Install cables as required for construction and staging. Furnish and deliver remaining cable to the Chicago Transit Authority, West Shops, Attn: Manager, Signal Maintenance.
3. Wayside track signage

a. Furnish and install new wayside signs associated with all impedance bonds removed and reinstalled or furnished and installed new.
b. Furnish and install new WA signs for all units removed and reinstalled or furnished and installed new.

4. Audio frequency track circuits, junction boxes, mounting brackets, hardware, clamps, platforms, other components and accessories necessary to complete the installation, in accordance with Section 34 42 20, Audio Frequency Track Circuits. Work shall include the adjustment and testing of all track circuits each time the components or wiring

are removed, relocated or disturbed.

5. Wayside junction boxes on a new platform:

   a. LK115JB and LK120JB

6. Grounding systems for the following wayside equipment:

   a. Junction boxes

7. Flashboards, at junction box and impedance bond platforms.

8. Work on drawings identified by –o-o-o- (In).

B. Furnish the following minimum cable quantities, portions of which may be utilized for work under this Contract:

   1) 37C#14 – 3000 FEET - VITAL SIGNAL CABLE (note that there are triple runs of express cables for the distance)
   2) 12C#14 –1000 FEET - VITAL SIGNAL CABLE
   3) 20TWPR#14 –3000 FEET - AUDIO FREQUENCY TRAIN DETECTION CABLE
   4) 1TWPR#14 –3000 FEET – AUDIO FREQUENCY TRAIN DETECTION CABLE
   5) 6PR#18 – No minimum quantity – STATION ANNUNCIATOR CABLE

C. Remove the following equipment and reinstall with new mounting hardware, wiring, platforms, cabling, clamps, impedance-bond to running-rail connections and miscellaneous components and accessories necessary to complete the installation, as indicated on Contract Drawings and in accordance with referenced Contract Specifications:

1. Impedance Bonds.

   a. Impedance bonds within new Damen platform area shall be mounted between running rails with new straps and deflector plates.

D. Test all wayside equipment, subsystem, components, cables and hardware. Test signal system in accordance with the final approved test procedures which will include the tests identified within the Specifications.

E. Design, fabricate and install support platforms for conduits, junction boxes and impedance bonds, as indicated on Contract Drawings and in accordance with referenced Contract Specifications.

3.04 SIGNAL WAYSIDE WORK DESCRIPTION

A. Furnish and install new junction boxes on a new platform on both north and south ends of Damen station on the track access platform, as shown on the drawings. Furnish and install new signal cable (20TWPR #14, 37C #14, & 12c#14) between junction boxes as shown on the drawings. Furnish and install local cables (1TWPR#14 and 12c#14) as shown on the drawings to

connect all impedance bonds to the appropriate junction boxes. Furnish and install all temporary supports for the existing cable while this work takes place. Protect and remove existing and temporary cables when finished placing the new cables in service. Work methods shall maximize the lengths of cables that are salvaged, and shall be conducted in a fashion that results in no more than a 5% loss of the existing lengths, unless otherwise approved by the Commissioner. New junction boxes shall be placed in service prior to the start of track support structure work.

B. Furnish, install and protect temporary bypass signal cables and messenger between junction boxes to facilitate station construction. Furnish, install and protect temporary cables and messenger from junction boxes to impedance bonds to facilitate station construction. Temporary cables shall include 20TWPR#14, 37c#14 and 1TWPR#14 cables and shall meet the requirements of the final cables.

C. Furnish and install new electrical conduit systems, including raceways, expansion couplings, support brackets and hangers. Electrical conduit systems shall be coordinated with other station electrical work and shall conform to the requirement for station electrical work. A minimum of three galvanized rigid conduit runs, 4" inner diameter minimum, shall be installed. One conduit run shall be spare, and only two will be utilized for routing the express signal cables through the station. Conduit runs shall be straight for the entire length of the run without requiring any intermediate pull boxes. Conduit supports shall be shared between these runs and the station electrical conduits. Expansion couplings shall be furnished and installed in the vicinity of all expansion bents along the runs. Couplers may be staggered, but shall be between adjacent supports on either side of the expansion bents

E. Furnish and install new messenger system, including cable, supports and brackets. Existing messenger and support brackets that are not disturbed by station demolition and construction may be reused. Messenger system shall be throughout the limits shown on the Drawings. This work shall include: systems under/within the southbound Damen station platform up to the limits of the conduit system, from the south limits of the station to the signal junction boxes south of the station, from the conduit system continuing north of station through the existing Randolph station area that is being demolished up to the signal junction boxes north of the Randolph station, a local messenger system along the southbound platform located under the platform edge and all cross runs to equipment and platforms. Furnish and install additional brackets to route cables past the stations during all phases of demolition and construction.

F. Furnish cable reels and deliver to CTA all existing 20pr#14 and 37c#14 cables that are removed in the course of the Contract work, as well as the balance of Section 3.03B cables.

G. Provide to CTA the latest version of Rockwell Automation software required to perform workstation modifications. Furnish and deliver to the Chicago Transit Authority, HQ at 567, Attn: Manager, Signal Engineering Rockwell's FactoryTalk View Site Edition Bundle catalog no. 9701-VWSS000CW25LENE, Site Edition Client catalog no. 9701-VWSCWAENE, Site Edition Station catalog no. 9701-VWSB000AENE, View Studio catalog no. 9701-VWSTENE and KEPServer Enterprise catalog no. 9301-OPCSRVENE.

3.05 FIELD QUALITY CONTROL

A. Adjustment, troubleshooting and testing of all audio frequency track circuits, receive only circuits, modules, and impedance bond equipment shall only be performed by qualified personnel who have been approved under this Contract for that purpose.

B. Validation, troubleshooting and testing of signal equipment shall only be performed by qualified personnel who have been approved under this Contract for that purpose.

C. Test work installed under this Section, whether new or removed and replaced, as described in Section 34 42 91, Signal System Tests.

D. Test all signal equipment to manufacturer recommended settings. Written approval is required from Authority for settings outside of manufacturer and Authority recommended settings.

E. CTA will only provide personnel to witness Contractor adjustment and testing. The Contractor must have personnel and material on site to repair damages that result from activities or work associated with this Contract. The Contractor shall provide personnel to clear any grounded or partially grounded running rails in the limits of the track replacement.

F. Maintain as-built documentation at each housing and location, and provide final as- built drawings as required under Section 34 42 04, Signal System Drawing Requirements.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The work of Signal Construction shall not be measured for payment.

4.02 PAYMENT

A. No separate payment shall be made for the work covered in this section. Payment for the Work of Signal Construction shall be included in the contract lump sum price as shown in the Schedule for Prices for SIGNAL AND TRAIN CONTROL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

SIGNAL AND TRAIN CONTROL WORK: 344200

END OF SECTION

SECTION 34 42 03
EQUIPMENT REMOVAL

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. The work to be done under this Section consists of the removal of existing signal material, equipment and facilities with instructions for their dispersal or, protection of such to permit new installation in the surrounding area.

a. The following instructions apply:

i. Remove and Replace.

ii. Remove and Salvage.

iii. Remove and Scrap.

iv. Protect in Place.

B. Related Sections:

1. Reference Plans.
2. Contract Drawings.

1.02 SUBMITTALS

A. Submit the following for approval by the Authority.

1. Remove and Replace spread sheets and report including the following:

a. Item identification.
b. Item serial number (where applicable).
c. Item removed from (including stationing and GPS coordinates of relay house/room or tower location and rack number if applicable).
d. Itemized condition of item prior to removal.
e. Item to be relocated to (including stationing and GPS coordinates of relay house/room or tower location and rack number if applicable).
f. Bench testing inspection to be completed.
g. Packaging procedures.
h. Contractor area used for storage.
i. Itemized condition of item upon completion of reinstallation.
j. Installation and inspection procedure.

2. Remove and Salvage spread sheets and report including the following:

a. Item identification.
b. Item serial number (where applicable).
c. Item removed from (including stationing and GPS coordinates of relay house/room or tower location and rack number if applicable).
d. Itemized condition of item prior to removal.
e. Packaging procedures.
f. Contractor area used for storage.
g. Itemized condition of item when delivered to the Authority.
h. Authority signature of receipt.

3. Remove and Scrap spread sheets and report:

a. The Contractors “Certificate of Dumping Facilities”.

4. Protect in Place spread sheets and report including the following:

a. Item location (including stationing and GPS coordinates of relay house/room or tower location and rack number if applicable).
b. Item identification.
c. Itemized condition of item prior to protecting.
d. Procedure including method and means of protecting item.
e. Condition of item upon removal of protection.

1.03 QUALITY ASSURANCE

A. Items removed that are intended for reinstallation or returned to the Authority to be packaged and treated so as not to cause damage or accentuate any damage that may have been present upon removal.

1.04 DELIIVERY, STORAGE, AND HANDLING

A. Any areas or facilities used by the Contractor for storage of items which are intended to be reinstalled in accordance with this Specification and the Contract Documents or delivered to the Authority to provide protection from any damage including, but not limited to the weather and humidity. Relative humidity to not exceed 70 percent.

B. Any damage to items removed for replacement, removed for delivery to the Authority or protected in place that is caused after the initial itemized condition assessment to be deemed to be the Contractors responsibility. Under these circumstances the Contractor will be responsible for the satisfactory repair to the Authority’s acceptance or complete replacement of the damaged items.

PART 2 - PRODUCTS

2.01 MATERIALS

A. The Contractor to provide wooden crating, pallets, boxes, cartons, empty cable reels, and light steel strapping or equivalent tying material, all in quantities sufficient for transporting and protecting any remove and replace in field or remove and salvage items consigned to the Authority's stores, yards, or shops.

B. The Contractor to provide marking materials including both tape and permanent marking pens to identify units of equipment and components for disposition and material audit purposes.

PART 3 - EXECUTION

3.01 REMOVE AND REPLACE

A. Any equipment that is to be removed for reinstallation to support the work under this Contract must be fully protected by the Contractor against damage or loss until final reinstallation and acceptance by the Authority.

B. The Contractor to submit condition assessment spread sheets and reports (including photo's is acceptable) prior to removal and after reinstallation.

C. Reinstalled items to be inspected for damage and tested in accordance with the approved installation and operating test procedures.

D. Items for removal and replacement are as defined in the Contract Documents and specified below:

1. None

3.02 REMOVE AND SALVAGE

A. Any equipment that is to be removed and salvaged (returned to the Authority) to support the work under this Contract must be fully protected by the Contractor against damage or loss until accepted by the Authority.

B. The Contractor to submit condition assessment spread sheets and reports (including photo's) prior to removal and delivery to the Authority.

C. Items to be removed intact, without damage, and returned to the Authority to include the following:

1. Vital relays
2. Vital and Non-vital processors
3. AF-500, AF-800 and AFTC-2 circuit boards and card files
4. Relay house/room equipment designated for salvage by CTA
5. Wayside signal equipment designated for salvage by CTA.

3.03 REMOVE AND SCRAP

A. All scrap materials to become the property of the Contractor and to be disposed of away from the project site at the locations designated in the Contractor's "Certificate of Dumping Facilities" in the Contract Proposal. These scrap materials to include but not be limited to the following:

1. All wayside signal equipment and foundations
2. Local and express cable
3. Relay houses

3.04 PROTECT IN PLACE

A. Any equipment that is to be untouched within the area of construction and returned to service to be fully protected by the Contractor against damage until returned to service and accepted by the Authority.

B. The Contractor to submit condition assessment spread sheets and reports (including photo's is acceptable) prior to protecting items.

C. Protected items to be inspected for damage and tested in accordance with the approved installation and operating test procedures.

3.05 REPAIRS AFTER REMOVALS

A. Where existing equipment is removed from the right-of-way, the right-of-way to be restored to its normal condition.

1. For elevated structure locations where existing signals and impedance bonds, etc. are removed, any resultant holes within the walkways to be replaced with a new section of approved walkway. (not applicable to this Contract)
2. In ballasted track areas where pieces of equipment, foundations, cable, etc. are removed, new fill and ballast to be installed and leveled to existing grade.
3. In tunnels where supports, brackets, etc. have been removed, the holes remaining in concrete to be patched with fill approved by the Authority.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The work of EQUIPMENT REMOVAL shall not be measured for payment.

4.02 PAYMENT

A. No separate payment shall be made for the work covered in this section. Payment for the Work of EQUIPMENT REMOVAL shall be included in the contract lump sum price as shown in the Schedule of Prices for SIGNAL AND TRAIN CONTROL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

B. Signal and Train Control Work: 344200

END OF SECTION

SECTION 34 42 04
SIGNAL SYSTEM DRAWING REQUIREMENTS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Requirements for final design drawings
2. Requirements for as-built drawings

B. Related Sections:

1.02 SUBMITTALS

A. Submit drawings described in this section for review by the Authority:

1. Before submitting, thoroughly check drawings for both compliance with Contract Documents and presentation. Check the following at a minimum:

   a. Conformance to the Specifications
   b. Logical grouping and arrangement of subject matter
   c. Accuracy
   d. Legibility
   e. Neatness
   f. Line quality
   g. Lettering quality
   h. Reproduction quality
   i. Inclusion of Contract specified interfaces with related contracts.

2. Stamp drawings certifying that they have been checked: "This drawing/document has been thoroughly checked and complies with the Contract Documents and field measurements and the item fits with adjoining work except as noted."
3. Drawings submitted without stamp of approval and certification, or which are incomplete, contain numerous errors, have not been checked, or have been checked only superficially will be returned unchecked by the Authority for resubmission by the Contractor.

B. Temporary Drawings:

1. Submit drawings for review.
2. Details of design will be left to Contractor, who to be responsible for safety and successful construction of Work.

C. Final Design Drawings:

1. Submit as packages of drawings germane to a particular location, subsystem or family of circuits all at one time.
2. This logical grouping of drawings, sufficient to completely cover the subject concerned, to be known as a Submittal Package.

D. Plan Books:

1. Book of Plans: Assemble drawings into plan books consisting of all design drawings associated with a particular relay house/room or location, including the following:

   a. Circuit drawings for all signal system components controlled by that particular house
   b. Double line locations plans up to house limits plus 1000 ft.
   c. Control line drawings up to house limits.
   d. Block diagrams for microprocessor and local signal communications systems
   e. Apparatus tabulation
   f. Main Terminal Board and signal rack layouts
   g. Signal power distribution and power loop layouts
   h. AC Service single line plan
   i. Relay house hotel electrical, fire suppression, and intrusion details and circuits
   j. Drawings from adjacent relay houses/rooms to show non-local portions of traffic and other line circuits appearing in house/room.
   k. Circuit and layout drawings for field equipment controlled from relay house/room and pertinent location and cable plans.

2. System-wide plan book: Include track plans, location plans, cable plans and typical drawings.
3. Single Line Drawings: Provide a laminated copy of the branch single line drawings in every signal house, two additional laminated copies to CTA Engineering, and the CAD and PDF versions of the drawings. Single line drawings to be completed prior to any signal cutovers. Necessary revisions to single line drawings to be made and resubmitted before close out.

1.03 CLOSEOUT SUBMITTALS

Within 30 days of substantial completion, submit as-built drawings in accordance with Closeout Procedures.

PART 2 - PRODUCTS

2.01 GENERAL DRAWING REQUIREMENTS

A. Contractor to be solely responsible for correctness of Contractor-furnished drawings, and for correctness of existing drawings modified by Contractor and included in final design submittals.

B. Contractor to provide a complete set of drawings including existing drawings containing no modifications.

C. Drawings to show design, dimensions, connections, and other details necessary to demonstrate that Contract Documents are accurately interpreted.

D. Drawings to:

1. Contractor to adhere to the latest version of CTA CAD Standards currently dated January 2013 Rev 3.
2. Establish actual detail of manufactured and fabricated items.
3. Indicate proper relation to adjoining work.
4. Amplify design details of mechanical and electrical equipment in the physical spaces in structures.
5. Incorporate minor changes of design or construction details to suit actual conditions.
6. Drawings to be line drawn graphics, image, import files, reference drawings attachment and overlays are not acceptable.
7. Blocks are acceptable for individual elements and to continue descriptive names.
8. Each element to be located on separate and unique layers ie track, trip, relay, signal etc.
9. Indicate location, sheet number and a brief descriptive description in the filename.

E. Submit detailed drawings as Shop Drawings:

1. Showing construction of each part of the Work.
2. Demonstrating compliance of a product or method of installation.
3. As specified in other sections of these Specifications.

F. Shop drawings to include:

1. Fabrication details.
2. Bending schedules for reinforcing steel.
3. Location and details of construction joints in concrete.
4. Catalog cuts of equipment or fixtures.

5. Wiring or piping diagrams.
6. Data sheets and performance curves for electrical, mechanical, or other equipment.
7. Other data supplementary to signal system data required by Authority.

G. Coordination:

1. Where separate sections or trades are involved, coordinate drawings.
2. Submit drawings coordination drawings in composite form, clearly designating which trade will perform which work, where required by Authority
3. The words "work by others" will not be accepted.

H. Adjoining Work:

1. Show proper connections with adjoining work in detail.
2. Where adjoining work requires drawings, submit for approval at same time so that connections can be accurately checked.

2.02 SUBMITTAL PACKAGES AND PLAN BOOKS

A. Furnish books of specific Signal System drawings for specified submittal packages and plan books.

B. Book to consist of the following:

1. Protective cover and backing sheets.
2. Device for binding the left hand edges of drawings firmly, but in such a manner that drawings may be easily added, removed, or replaced without damage to drawings.
3. Name of submittal package and name and location of plan book printed on cover sheet in two inch high letters.

C. Content of books of drawings to include the following:

1. Index sheet of the same size as drawings.
2. Group of drawings assembled in logical order.

2.03 FORMAT REQUIREMENTS FOR DRAWINGS

A. Use Authority's standard 24-inch by 36-inch standard title block or as otherwise specified; other size drawings to require the approval of the Engineer.

B. Drawings to not be crowded or cluttered, but to be arranged to be easily readable.

C. Show complete circuits on each drawing if possible with minimum of circuit continuations.

1. When continuations are used, include clear and specific reference to continuation sheet.
2. Continuations to overlap on both sheets for clarity when reading prints.

D. Local circuits:

1. Show relay coils, timers, motors, or other operated devices near right or left border of the drawing wherever practical; right border is favored.
2. Lay out contacts in circuits in geographical succession insofar as possible and practical.

E. Line circuits:

1. Arrange to geographically match track layout.
2. On plans, only line circuits to appear on right and left sides of drawing.

F. Relay contacts: Lined up one below the other insofar as practicable.

G. Relay nomenclature:

1. Print in three lines, with the following information:

   a. Top: Rack Location.
   b. Middle: Name Identification.
   c. Bottom: Function Description.

2. Example:
   (4H3)
   9
   ASR
3. Show above relay coil or contact symbol.

H. Stick contacts: Line up under coil of controlling relay.

I. Track and Signal Plans: Show survey station for wayside signal equipment including the following:

1. Signals.
2. Train stops.
3. Points of switch.
4. Track circuits.
5. Relay houses.
6. Relay cases.
7. Junction boxes.

J. Circuits:

1. To not be drawn as schematics; draw to reflect actual wiring of circuits.
2. Circuitry to be presented on drawing with minimum of crossed or offset lines.
3. Circuit nomenclature to show "break" numbers to facilitate testing and recording of conditions of individual conductors.
4. Arrange circuits such that no more than two wires are shown connected to a single terminal or contact pin.
5. Use uniform method to indicate actual location of double wire connections when it is not desirable to show both wires at point of termination.
6. Circuit drawings to provide sufficient information by means of contact and terminal numbering to enable easy tracing and testing of circuits.
7. Circuit wiring:

    a. Minimum distance between lines: 0.40 inch.
    b. Lettering or printing: Minimum 0.10 inches high.
    c. All spacing to be in multiples of tenths of inches.

K. Use AREMA Standard symbols and nomenclature when CTA symbols and nomenclature are not available..

L. When final circuit is not wired as shown on the Contractor's final design, revise drawing to indicate actual wiring before final as-built drawings are made.

2.04 FINAL DESIGN DRAWING TYPES

A. Title: Control Line Diagrams

1. Description: Horizontal scale drawings.
2. Horizontal Scale: 1 inch equals 100 feet.
3. Vertical Scale: 1 inch equals 30 feet.
4. Show track configuration including the following:

    a. Control lines.
    b. Grade and curve profile. Including calculated comfort and overturning speed for each of the curves and the chaining limits of curves and grade changes.
    c. North direction arrow.
    d. Station Equations
    e. Location with track marker chaining of signal system facilities pertinent to Contract such as:
        i. Signals.
        ii. Switch and lock movements.
        iii. Insulated Joints
        iv. Impedance Bond & Receive Junction Locations
        v. Junction cases.

vi. Instrument housings.
vii. Station platforms.

B. Title: Double-Line Track and Signal Plans.

1. Description: Horizontal drawings.
2. Scale: 1 inch equals 40 feet.
3. These drawings to overlay the signal equipment on CTA-provided existing Common Track Baseline Drawings (1600 drawings).
4. Update drawings with all signal wayside equipment and relay house locations all to scale.

C. Title: Single Line Diagram

1. Description: These drawing to be condensed drawing of an entire branch showing locations of all signal equipment to be used as a quick reference as necessary. Drawing limits of the single lines drawing depicted should extend at least two full track circuits past the limits of the project area or as otherwise agreed to by CTA.
2. Drawings to be sized and printed at 11-inch by 17-inch size.
3. Drawing set to not be to a specific scale but relative distances on the drawing to be accurate.
4. Track to be represented by a single line.
5. Drawings should have relative direction correct and an arrow indicating north direction.
6. Drawing set should ideally be condensed to 1-4 pages.
7. Drawing should show the following supplemental information with track marker chaining listed

a. Cross Street names with indication whether it crosses the tracks over, under, or at grade
b. Station platforms
c. Subway portals
d. Crossovers with common name and turnout number
e. Listed maximum allowable cab signal speed for each track circuit
f. Frequency and code rate for each AF track circuit.
g. Lengths of track circuits
h. Signal house/case control limits
i. All curve limits with calculated comfort speed listed
j. Interlocking approach locking limits
k. Grade crossing warning control limits
l. Station Equations
m. Right-of-way access and emergency exit locations

n. Any other pertinent information as determined by the Engineer

8. The following equipment should be visually listed on the drawing with track marker chaining. Equipment that is located within 5 ft of each other does not have to be listed with separate chaining (e.g. signals with train stops near IJs)

a. Impedance bonds & receive points
b. Insulated joints
c. Wayside signals & train stops
d. Route selectors
e. Switch machines of all types
f. Signal houses
g. Signal cases and junction boxes
h. Grade crossing equipment
i. Worker ahead and ME signals
j. AVI equipment
k. Control Panel Locations
l. Any other pertinent signal equipment

D. Title: Arrangement Plans.

1. Description: Drawings showing arrangement of one or more of the following:

a. Terminal boards.
b. Instruments.
c. Components in one or more of the following:
    i. Relay house.
    ii. Relay case.
    iii. Rack.
    iv. Junction box.
    v. Cabinet.
    vi. Module.

2. Include the following:

a. Contact arrangement.
b. Working and spare contacts of vital and non-vital relays.
c. Cross-reference to circuit drawing where working contact appears.

E. Title: House/Room Layout Plans.

1. Description: Drawings showing location of signal equipment in relay room or house.
2. Include the following equipment:

a. Equipment racks.
b. Entrance racks.
c. Cable trays.
d. Control panels.
e. Power distribution equipment.

3. Show critical room and equipment dimensions.

F. Title: Installation Layout Plans.

1. Description: Drawings showing mechanical installation details of signal equipment such as the following:

a. Signals.
b. Switch and lock movements.
c. Snowmelter layouts.
d. Train stops.
e. Cab signal control test loops.

G. Title: Cable Plans.

1. Description: Drawings showing point-to-point cable runs, cable make up, and conductor size.
2. Show double-line track configuration.
3. Identify each track circuit, signal, and related items of signal apparatus.

H. Title: Circuit Drawings.

1. Drawing title to include title of particular function(s) performed by circuits shown.
2. Description: Drawings showing required control, operating, and indication circuits.
3. Include the following:

a. Circuit nomenclature.
b. Terminal identification.
c. Fuse and resistor sizes.
d. Relays, with contacts identified by number and by coordinates to identify location of relay on instrument rack.
e. Show time relay time settings beneath corresponding time element relay symbol.

I. Title: Power Distribution Plans.

1. Description: Schematic drawings of required energy distribution systems or subsystems.

J. Title: Wiring Diagrams.

1. Drawing title to include title of particular piece of equipment shown.
2. Description: Drawings showing details of electrical connections for required signal system equipment.

K. Title: Cable Routing Drawings.

1. Description: Drawings showing cable routing, cable make up, and conductor size.
2. For interior cable routing within buildings, show the following:

    a. Building floor plans.
    b. Conduit, duct or raceway locations with identification and size.
    c. Cable, with identification and size.

3. For exterior locations, show the following:

    a. Relevant tunnel characteristics.
    b. Relevant elevated structures and supports.
    c. Raceway, with identification and size.
    d. Cable, with identification and size.

L. Title: Input/Output Drawings.

1. Description: Drawings showing assignment of inputs and outputs to microprocessor-based systems.
2. Include I/O charts summarizing the input and output assignments on each microprocessor unit.
3. Include detailed drawings describing input and output assignments at board level.

M. Title: Bill of Material Sheets.

1. Description: Drawings or documentation showing a complete breakdown of material including the following:

    a. Quantity.
    b. Location.
    c. Manufacturer.
    d. Part number information.

N. Title: Product Drawings.

1. Drawing title to include title of particular piece or type of equipment shown.
2. Description: Drawings showing dimensions and internal mechanical and electrical details of each piece of equipment or assembly.

O. Title: Temporary Plans.

1. Drawing title to include the purpose served.
2. Description: Drawings showing required temporary work, which will not remain as part of completed work.

2.05 EXISTING DRAWING REQUIREMENTS

A. Provide CAD and pdf sample version of each drawing type with the Design Validation submittal.

B. Revise and redraw existing drawings modified as a result of work performed under this Contract. The drawing template to match that of the existing plan set.

C. Submit drawings with final design submittals.

D. Submit marked up drawings showing changes to existing circuits and equipment.

1. Clearly identify changes using “O’s” and “X’s.”
2. Include on each drawing a legend stating “O-ed line = IN” and “X-ed line = OUT”.

E. Temporary Changes to Existing Drawings:

1. Submit marked up drawings showing temporary changes to existing circuits and equipment.
2. Clearly identify changes using “O’s” and “X’s.”
3. Include on each drawing a legend stating “O-ed line = IN” and “X-ed line = OUT”.

2.06 TEMPORARY DRAWING REQUIREMENTS

A. Temporary work and methods of construction including

1. for cribs,
2. cofferdams,
3. false work,
4. shoring,
5. decking,
6. protection in place,
7. form work, and for
8. other temporary work and methods of construction the Contractor proposes to use.

2.07 AS-BUILT DRAWING REQUIREMENTS

A. Upon completion of the work, submit plan books marked “as-installed.” The plan books and documents to reflect as-built conditions.

B. Include CAD drawings showing conduit routing and site specific construction details.

C. Include two marked up copies of as-built conditions.

D. As-built drawings should not include staging or temporary notes, references, or markings.

2.08 SOURCE QUALITY CONTROL

A. Factory wiring and testing of factory wired equipment:

1. Immediately update drawings or documents affected by a change in the circuits or equipment.

PART 3 - EXECUTION

3.01 VERIFICATION OF CONDITIONS

A. Verify dimensions and field conditions and check and coordinate drawings of each Specification section or trade with the requirements of all other sections and trades.

B. Before submitting drawings, coordinate work with adjoining materials or trades as required for proper and complete installation of work.

3.02 MODIFICATIONS TO EATING SYSTEMS

A. Submit existing drawings marked up to show temporary changes required during stages of placing portions of the work in service.

3.03 CAD DRAWINGS

A. The Contractor to provide one complete set of the approved type of CAD files of the final as-built drawings prior to final acceptance by the Engineer. These files to include all as-built modifications and approved drawings, and to, when used in the Authority’s CAD system, produce drawings identical to the Contractor’s final drawings.

B. All CAD files to conform to the CTA’s Engineering CAD Standard.

C. Drawing format to be AutoCad (*.dwg) and Adobe Acrobat (*.pdf). The media for transferring files to be of the following format:

1. USB flash drive with no file compression. The Contractor to furnish the USB flash drive of sufficient memory to at least contain all drawings associated with a single location. Single locations to not be split up among multiple USB flash drives.

D. The file names to correspond to the locations, and the electronic sheets to correspond to the final Drawings. Each sheet/file name will correspond to the sheet number and a description of what is contained on the sheet. Example: “18T0042_Control Limits (3 of 3).pdf”

3.04 FIELD QUALITY CONTROL

A. On-site installation and testing:

1. Maintain plan books in each relay house or room.
2. Immediately update drawings affected by a change in the circuits or equipment.
3. Maintain a second set of plan books at Contractor’s on-site headquarters.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The work of SIGNAL SYSTEM DRAWING REQUIREMENTS shall not be measured for payment.

4.02 PAYMENT

A. No separate payment shall be made for the work covered in this section. Payment for the Work of SIGNAL SYSTEM DRAWING REQUIREMENTS shall be included in the contract lump sum price as shown in the Schedule of Prices for SIGNAL AND TRAIN CONTROL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

B. Signal and Train Control Work: 344200

END OF SECTION

SECTION 34 42 09
SIGNAL ABBREVIATIONS AND DEFINTIONS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. This section summarizes the abbreviations and definitions required for this Contract.

B. Related Sections:

1. Drawings and general provisions of the Contract, including the General and Special Conditions, and sections of Division 1.

1.02 REFERENCES

A. Wherever in the Specifications or Contract Drawings the following terms are used, the intent and meaning to be interpreted as herein defined.

B. Pertinent provisions of the following listed standards to apply to the work of this Specification, except as they may be modified herein, and are hereby made a part of this Specification where the requirements of the following do not conflict with this Section of the Specifications.

1. Association of American Railroads:

a. Signal Manual Part 1.1.1 Specification of Technical Terms Used in Signaling.

2. Institute of Electrical and Electronic Engineers:

a. IEEE Standard Dictionary of Electrical and Electronics Terms.

C. In the event of a conflict between definitions, the following order of priority to be followed:

1. Definitions as contained herein.
2. AAR Signal Manual Part 1.1.1
3. IEEE Standard Dictionary.

1.03 DEFINITIONS

AAR: Association of American Railroads.

Alarm Condition: Any abnormal condition which requires the attention of an attendant or operator.

AF: Audio-Frequency or Auxiliary Feeder

API: Applications Interface

AREMA: American Railway Engineering and Maintenance Association.

Audible Alarm: The sounding of a bell, buzzer, or other acoustic device to draw the attention of the Control Operator to an alarm condition.

Audio House: A train control facility that houses ATP and ancillary equipment (such as power supplies, event recording and non-vital processor equipment) only. A facility that does not provide for interlocking control functions.

AWG: American Wire Gauge.

Authority: Chicago Transit Authority.

Automatic Local Control: A mode of system operation in which functions such as route initiation and dispatching is automatically performed by local equipment.

Automatic Routing System: A system to automatically establish route selection at a control point to permit the routing of trains in accordance with a pre-determined schedule or other method of automatic route selection.

Automatic Train Control (ATC): The system for automatically controlling train movement, enforcing train safety, and directing train operations. ATC includes subsystems for Automatic Train Protection, Automatic Train Supervision, and Automatic Train Operation.

Automatic Train Operation (ATO): The subsystem within Automatic Train Control which performs the on train functions of speed regulation, program stopping, and performance adjustment.

Automatic Train Protection (ATP): The subsystem within Automatic Train Control which maintains safe train operation. ATP subsystems include train detection, train separation, interlocking, and speed limit enforcement.

Automatic Train Supervision (ATS): The subsystems within Automatic Train Control which monitors and provides controls necessary to direct the operation of a system of trains in order to maintain intended traffic patterns and minimize the effects of train delays on the operating schedule.

Auxiliary Switch Operation: A manual control which permits operating a switch movement without clearing a signal. This control is performed via an Auxiliary Switch Lever located on a local control or tower panel.

Ballast Impedance: The total inter rail impedance caused by electrical leakage paths of a given section of electrically isolated unoccupied track.

Ballast Resistance: The total inter rail resistance caused by electrical leakage paths of a given section of electrically isolated unoccupied track.

B-Point: Receiver equipment that is installed within the limits of an AF track circuit (bound on both ends by impedance bonds) to create a subzone of train detection within the boundaries of the track circuit. Equipment installed on the wayside picks up the coded train detection signal from the rails via direct wire connections, inductively via wire loops or a combination of both. Receiver equipment includes a means for vitally decoding and verifying the received signal and driving a vital train detection relay.

BCH (BOSE CHAUDHURI HOCQUENGHEM) Code: A class of cyclic error-detecting codes that are particularly effective in the detection and correction of randomly occurring errors in an array of data bits.

Block: A length of track of defined limits, the use of which by trains is governed by block signals.

Bootleg: A protection for track wires where the wires leave the ground near the rail.

Bus: A conductor or a group of conductors that are terminated as a common connection for two or more circuits.

CAD: Computer-Aided Design

Call-On Signal: A proceed wayside signal aspect authorizing a following train movement into an occupied block, with the route lined and locked.

Central Control Office: A location from which the functions of a traffic control system or of interlockings are controlled and indicated.

Channel Bank: A device which samples, quantizes, and codes/decodes voice frequency or data circuits into/from a digital pulse code modulation (PCM) signal.

Circuit, Vital: Any circuit which affects the safety of train operations.

Civil Speed Limit: The maximum speed allowed in a specified section of track as determined by physical limitations of the track structure, train design, and/or passenger comfort.

Communication Based Train Control (CBTC): A railway signaling system that makes use of telecommunications between the train and track equipment for traffic management and infrastructure control.

Control (Supervisory): A coded message from a control console to a field location to change the status of signal equipment for train operation.

Controlled Signal: A block signal located at a control point and capable of being controlled by a control operator.

Control Point: A location so designated where signals, switches, traffic direction and/or other functions of a traffic control system are controlled either locally or from a central control office.

Cross Bond: An electrical connection from one track to another track to distribute traction power return currents.

Crossover: Two turnouts, with track between the frogs, arranged to form a continuous passage between two tracks.

Crosstalk: Undesirable interference created by coupling between one system and another system or from one portion of a system to another portion of the same system.

CRT: Cathode Ray Tube

CTA: Chicago Transit Authority

CTC: Centralized Traffic Control, Automatic Block Signal System - A block signal system where the use of each block is governed by an automatic block signal, cab signal, or both. A roadway signal operated either automatically or manually at the entrance to a block

Data Circuit: A digital signal which conforms to the RS 232 C standard for serial transmission at a baud rate of 9600, or a formatted signal for direct digital input to a channel bank at speeds up to 64 Kb/s.

Data Transmission System (DTS): A bi directional digital communications system between Central Control and field, or between other locations.

Downstream: For a given direction of travel, locations beyond a specified reference point. Used interchangeably with AAR term "in advance of".

Electro Pneumatic Switch: A track switch operated by an electro pneumatic switch and lock movement.

Electro Pneumatic Valve: A valve electrically operated which, when operated, will permit or prevent passage of air.

Entrance-Exit Type Route Control: Automatic route control implemented by defining an entrance point and an exit point. Often referred to in its abbreviated form: eNtrance-eXit or NX.

EP: Electro pneumatic.

EPROM: Erasable programmable read only memory.

Fiber Distribution Panel: A rack mounted device for the connectorized mating of fiber optic pigtails and the mounting of wave division multiplexers (WDM).

Flash Memory: A type of electrically erasable programmable read-only memory (EEPROM).

Fleet: A method of route control in which a route request and establishment is not cancelled by the passage of a train.

FO: Fiber Optic

FRA: Federal Railroad Administration

Hertz (Hz): The unit of frequency in cycles per second.

Indication (Supervisory): A coded message from a field location to a control console to report the status of signal equipment or train operation.

Insulated Joint (IJ): A rail joint in which electrical insulation is provided between adjoining rails.

Interface: The interconnection or inter relationship between two or more systems, subsystems, persons, or contracts, required to ensure continuity and proper operation.

Interlocking: An arrangement of signals and signal appliances operated from an interlocking machine and so inter connected by means of electric locking that their movements must succeed each other in proper sequences, train movements over all routes being governed by signal indication.

Interlocking Limits: The length of track or tracks between opposing wayside signals controlled by an interlocking.

ICEA: Insulated Cable Engineers Association

Joint Electron Device Engineering Council (JEDEC): Cooperative effort of Electronic Industries Association (EIA) and National Electrical Manufacturers Association (NEMA).

Junction: A location where train routes converge of diverge.

LAN: Local Area Network

Local Distribution Frame (LDF): A small or medium sized cross connect and common termination point for voice frequency and data copper cables, which is subordinate to the main distributing frame (MDF), from which all local voice frequency and data circuits to be accessible.

Local Manual Control: A mode of system operation in which functions such as route initiation and dispatching are controlled manually by local equipment.

Locking: The electrical or mechanical establishment of a condition for a switch, interlocked route, speed limit, or automatic function which cannot be altered except by a prescribed and inviolate sequence of unlocking.

Main Distributing Frame (MDF): A medium or large sized cross connect and common termination point for voice frequency and data copper cables from which all voice frequency and data circuits to be accessible.

Married Pair: Two rail cars which are semi permanently coupled together and share certain common equipment. This consist is often referred to by CTA Rail Operations as a ‘deuce’ and is assumed to be 96’-6” in length.

Maximum Authorized Speed (MAS): The highest speed limit which is authorized.

Mean Time Between Failures (MTBF): The average time that a piece of equipment will operate without a failure.

Mean Time to Repair (MTTR): The average time required to restore a piece of equipment to operation after the report of a failure. This time is measured from the time troubleshooting and repair work begins until restoration is complete.

Maintenance-of-Way (MOW): Having to do with the installation and maintenance of track and related structures to facilitate the operation of trains.

Multiplexer Demultiplexer (MULDEM): A device for combining a number of individual low speed digital channels into a common high speed digital bit stream for transmission over digital facilities.

NEMA: National Electrical Manufacturers Association.

Noise, Electrical: Interference brought about by undesirable random voltage or currents.

Outside Plant (OSP): Any device or apparatus intended for permanent installation in a non-protected, exposed environment.

Penalty Brake Application: Automatic brake application at the B3 braking rate.

Pothead: A method of protecting cable ends from the weather and to provide means of disposing of static stresses set up at cable ends.

Power Bond: A conductor of low resistance providing a path for return of propulsion current at non insulated joints, frogs, and switch points.

RAM: Random Access Memory.

Rapid Information Retrieval System: A static informational data bank accessed manually.

Reaction Time: The time used by equipment, operator, or both, that elapses between the moment an action is called for and when the desired result occurs.

Relay Case: A housing, located along the right of way, used to house signal apparatus and/or terminate underground or aerial cable.

Relay House (RH): A large walk in type housing, sometimes called a bungalow, which is used to house signal equipment and terminate cable at an interlocking or control point.

Relay Room (RR): Room located in tower buildings or at other strategic points to house signal control equipment.

Reliable Power Source: The primary source of power. Also referred to as the normal power source.

Remote Terminal Unit (RTU): The equipment which constitutes the field end of a Data Transmission System.

Reserve Power Source: The secondary power source, used upon failure of the primary source. Also referred to as the emergency source.

Right of Way Hazard: The existence of an abnormal condition on, or near, the tracks which could impair safe train movement.

Roadway Worker: Any employee of or contractor providing work to a railroad, whose duties include inspection, construction, maintenance or repair of railroad track, bridges, roadway, signal and communication systems, electric traction systems, roadway facilities or roadway maintenance machinery on or near track or with the potential of fouling a track, and flagmen and watchmen/lookouts.

Route: A specified succession of contiguous blocks over which trains operate between two controlled interlocked signals.

RP: Receive-only Point. See *B-Point*.

Service Brake: Retardation produced by the primary train braking system.

Signal: An appliance which conveys information governing train movements, either in a stationary wayside location or in a mobile vehicle-mounted location, responsive to dynamic information based on train position.

Signal Aspect: The appearance of a fixed signal conveying an indication as viewed from the direction of an approaching train; the appearance of an automatic speed control cab signal indicator as viewed in the cab.

Signal Bond: A conductor of low resistance providing a path for the signal track circuit current at non-insulated joints.

Signal Indication: The information conveyed by the aspect of a signal.

Snowmelter (SM): An electric, gas, or hot air heater or element used to melt snow and ice at designated locations to allow proper operation of equipment.

Station Distribution Frame: A LDF installed within a station communication room.

Subsystem: A subsystem comprises elements within a system which are interconnected to perform a specific function.

Switch and Lock Movement: A device which performs the sequential functions of unlocking, operating, and locking a track switch.

Switch (Electric): A device be means of which an electric circuit may be opened or closed.

Switch (Track): A pair of switch points with their fastenings and operating rods providing the means for establishing a route from one track to another.

Switch Circuit Controller: A device for opening, closing or shunting electrical circuits, operated by a rod connected to a switch point.

Switch Point: A movable tapered track rail, the point of which is designed to fit against the stock rail.

Switch Test Key/Auxiliary Switch Operation: A device which permits operating a switch movement without clearing a signal.

Thru Routing: A method of entrance exit route selection design whereby intermediate signal calls are automatically initiated between available entrance and intermediate exit points by initiating only initial entrance and final available exit commands.

Track - An assembly of rails, ties, and fastenings over which cars, locomotives, and trains are moved.

Track Circuit: An arrangement of electrical and/or electronic equipment, including a length of the running rails, which permits detection of trains within the limits of the running rails.

Track Transformer: A transformer designed to couple electrical energy to and from the rails of a track circuit.

Traction Supply System or Traction Power System: The substations, feeder cables, contact rails or wires, switch gear and other equipment interfacing with public utilities or other power generation equipment and providing the electrical power for the movement of trains and the operation of their auxiliary systems.

Traffic Circuit: A circuit which controls and maintains the direction in which a signal system will accept and govern train movements.

Traffic Control System: A signal system that permits trains to operate in both directions on the same track governed by cab signal indications.

Trailable Switch Operating Layout: A device which performs the functions of operating a track switch. It can operate the track switch either in a motor driven mode, or can be trailed through by a train.

Train Control Facility: A room or equipment house that contains train control system components.

Train Control System - The system for controlling train movement, enforcing train safety, and directing train operations.

Train Detection Equipment: The track circuits and associated equipment used to detect the presence of trains.

Train Identity: The alpha numeric code assigned to each train which contains, as a minimum, the elements of train destination, direction, and train number.

Train Shunt Impedance: The electrical Impedance between running rails when spanned by train wheels and axles.

Train Stop: A track mounted device located at wayside signals which actuates the carborne side trip emergency mechanism, causing an emergency application of the train brakes, when a train passes a signal displaying a STOP indication. Also referred to as trip, track trip, and trip stop.

Turnout: An arrangement of a track switch and frog with closure rails that provides the means for rolling stock to be diverted from one track to another.

Uninterruptible Power System (UPS): An auxiliary power system which provides an uninterrupted AC power source during a normal power source failure.

Unsafe Condition: Any condition which endangers human life or property.

Upstream: For a given direction of travel, locations, which have been passed prior to reaching a specified, reference point. Used interchangeably with AAR term "in approach of."

Voice Frequency (VF): An analog alternating current signal suitable for voice transmission with a bandwidth of 4 kilohertz.

Wayside Equipment - Train control or movement apparatus which is located along the track or wayside as opposed to the control center or other remote location.

Wayside Signal - A signal of fixed location along the track right-of-way.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The work of SIGNAL ABBREVIATIONS AND DEFINITIONS shall not be measured for payment.

4.02 PAYMENT

A. No separate payment shall be made for the work covered in this section. Payment for the Work of SIGNAL ABBREVIATIONS AND DEFINITIONS shall be included in the contract lump sum price as shown in the Schedule of Prices for SIGNAL AND TRAIN CONTROL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

B. Signal and Train Control Work: 344200

END OF SECTION

SECTION 34 42 20
AUDIO FREQUENCY TRACK CIRCUITS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. The work to be done under this Section to:

   a. Be done in accordance with the approved block design performed by the Contractor.

   b. Consist of furnishing and installing the following:

      i. Audio frequency double rail track circuits.

      ii. Audio frequency command loops to provide continuous cab signal aspects for trains where audio frequency track circuits will not be installed.

      iii. Receive-only equipment.

2. Provision for track circuits, command loops and receive-only points to include but not be limited to:

   a. Cable.
   b. Conduit.
   c. All mounting hardware.
   d. Junction boxes.
   e. Connections.
   f. All other equipment and collateral work to complete the installation, ready for operation.

B. Related Sections:

1. 34 42 01 Basic Signal System Technical Requirements.
2. 34 42 02 Design Block Criteria.
3. 34 42 04 Signal System Drawing Requirements.
4. 34 42 32 Impedance Bond Layouts.
5. 34 24 30 Traction Power Rail Connections and Running Rail Bonding.
6. 34 42 30 Relays.
7. 34 42 38 Miscellaneous Components and Products.
8. 34 42 40 External Signal Cable.
9. 34 42 41 Internal Signal Wire and Cable.
10. 34 42 62 Junction Boxes.

11. 34 42 71 DC Power Supplies.
12. 34 42 76 Grounding Equipment.
13. 34 42 85 Vital Microprocessor Interlocking System.
14. 34 42 90 Technical Support.
15. 34 42 91 Signal System Tests

1.02 SUBMITTALS

A. The Contractor to submit the following plans and information for approval by the Authority:

1. Mechanical and circuit drawings of the audio frequency track circuits and receive-only points.
2. Mechanical and electrical drawings of the audio frequency loop layouts.
3. Complete performance data of each type audio frequency track circuit and receive-only point.
4. A complete reliability report must be made for each type of audio frequency track circuit to be utilized. The report to be included with the audio frequency track circuit product data submittal.
5. Catalog cuts and descriptive literature for all material as specified herein and as shown on the Contract Documents.
6. Factory test procedures.
7. Installation and field test procedures.
8. Complete electrical schematic drawings and bills of materials for all:

    a. Modules.
    b. Card files.
    c. Synchronizers.
    d. Circuit boards.
    e. Impedance bonds.
    f. Receive only units.
    g. Loop drivers.
    h. Filters.
    i. Components and all other equipment associated with the audio frequency track circuit and cab signal system.
    j. Detailed audio loop layout drawings.

9. Submit documentation demonstrating compatibility of the proposed system after successfully completing a nine-month in-service acceptance test as described in Section 34 42 20.3.A, with the installation of a minimum of two adjacent track circuits and on an existing section of the CTA chosen by the Authority for test purposes.

10. White paper documenting future capabilities.

1.03 QUALITY ASSURANCE

A. Audio frequency track circuits to be designed, installed and tested in accordance with AREMA Signal Manual Parts 8.1.1, 8.2.1, and 8.6.1 where the Manual Parts do not conflict with this Specification.

1.04 DELIVERY, STORAGE AND HANDLING

A. All equipment to be protected from damage throughout delivery, storage and handling.

PART 2 - PRODUCTS

2.01 GENERAL

A. General requirements for audio frequency track circuits are as follows:

1. All active electronic equipment to be located in Relay Houses, Relay Rooms, Signal Towers, or as specified herein.
2. Plug couplers or terminals to be wired to modules to provide external connection of the speed selection network and other external wiring associated with the module.

    a. No more than one module to be wired to a plug coupler. All modules to be typically wired to the coupler. This to include all speed command points, not only those that are connected to the external network.

3. Modules to include a steady, un-coded train carrier setting for maintenance and troubleshooting purposes.
4. Cab signal equipment to include the Manufacturer's latest development to minimize susceptibility to interference from advanced propulsion systems, particularly AC propulsion motors and chopper controls.
5. Sufficient test points or a connected computer display to be provided to allow the viewing of the output waveforms and amplitude modulation rate and levels.
6. Visual indications to be provided for displaying the active commanded speed transmission and go command (speed transmission enabled) status. These indications may alternatively be displayed via a Signal Maintenance Workstation on the Signal network or through a light on track circuit module.
7. Equipment to be based on a design that has had successful installation and in service operation at CTA for a minimum of nine months. Where this requirement cannot be met, the product must go under a compatibility acceptance test as described in Part 3 A.
8. The track circuit must provide for broken rail detection of both running rails.

9. The track circuit must be capable of implementing and displaying temporary speed restrictions remotely from any computer connected to the signal network.
10. The transmitter and its associated equipment to be capable of operating a track circuit:

    a. Of at least 1.5 times the length of the longest track circuit in the approved block design with a minimum ballast impedance of five ohms per 1,000 feet.
    b. Of at least 700 feet in length with a minimum ballast impedance of five ohms per 1,000 feet located a minimum of 3500 feet from the transmitter, and utilizing twisted pair No. 14 conductors from the impedance bond to the transmitter and receiver.

B. Demonstration of Future Capabilities

1. Track Circuit System must provide for the following future capabilities. The track circuit product and associated system must be capable of providing these capabilities with only an upgrade of the carborne cab signal system and adjustments to the wayside application software. All necessary hardware and cabling must be installed as part of the project.

    a. Train detection via secure messaging between transmitter and receiver.
    b. Provide synthesized analog signals for cab carrier and cab speed codes.
    c. Train to Wayside communications for bi-directional data exchange.
    d. Easily upgraded to include Precision Berthing applications (Precision berthing to CENELEC SIL level 1).
    e. Provide bi-direction detection of proper berthing in station platforms (SIL 4 level).
    f. Supports upgrade to Automatic Train Operation.
    g. Supports upgrade to provide red signal enforcement (SIL 3 level).
    h. Automatic alarming of track circuits where the shunted receive voltage rises above a specific magnitude and where the un-shunted receive voltage drops to a specific magnitude.
    i. Ethernet interface for communication with adjacent processors and to support remote diagnostics. This includes remote monitoring and logging of track circuit train detection transmit and receive un-shunted and shunted voltages over time.

2. Provide a white paper documenting how the future capabilities requirement will be met, constraints regarding these features, and what scope elements must be added to future carborne specifications.

2.02 MODULES AND COMPONENTS

A. Each audio frequency track circuit module to be capable of generating all speed commands used on the CTA system.

B. Each track circuit module to be furnished with all components necessary to transmit all speed increments from the circuit maximum to 0 mph regardless if the intermediate speeds are or are not selected by the external network.

C. Each audio frequency track circuit module to be capable of providing temporary speed restrictions. The Temporary Speed Restriction (TSR) request will be considered non-vital but must be handled VITALLY by the Vital Microprocessor Interlocking (VMI) System and track circuit product. The VMI System or track circuit must retain memory of the previous state of a temporary speed restriction in the event of power outage or reset.

1. Physical Temporary Speed Restriction Dials:

   a. Adjustment to be from an externally accessible manual selector switch or other approved method.
   b. The TSR switch to be marked "0", “Restricted Speed”, "15", "25", "35", “45”, "55", and "70" to provide visual indication of what maximum speed has been selected.
   c. The TSR switch to be integrated into the cab speed selection through the VMI System. Interface to be via discrete vital inputs. TSR interface to the code rate generator circuit board to not be allowed.
   d. Speed selection logic to be designed so that the TSR input cannot override a more restrictive command from the control line speed selection logic.
   e. The TSR switch to have the capability of remote control. This functionality to be demonstrated prior to in-service testing and then disabled.
   f. The wiring for each selector switch to be encased in a nonconductive protective cover to guard against false power feeds.

2. Electronic Temporary Speed Restriction:

   a. Adjustment of the track circuit TSR may be done through a computer system connected to the Signal Network.
   b. Modifications to the settings will require a password protected log in by an approved user.

c. The following speed restrictions will be allowed from the circuit: “0”, “Restricted Speed”, “15”, “25”, “35”, “45”, “55”, and “70”.

d. Speed selection logic to be designed so that the TSR input cannot override a more restrictive command from the control line speed selection logic.

e. All digital TSR modifications will be logged with the date and the modification that was put in place and will allow for an entry by the user with a description field to input additional information regarding the setting.

f. User database to be on the Signal Network server and not be unique for each signal room/house.

g. The TSR settings will be graphically displayed to all users with access to the Signal Network including all Signal Maintenance Workstations provided on this project.

D. The transmitter and its associated equipment to be capable of operating a track circuit of at least 1.5 times the length of the longest track circuit in the approved block design with a minimum ballast impedance of five ohms per 1,000 feet.

1. The minimum current level for the 4550 Hz cab signal in the rail or in a loop to exceed 120 MA for the entering end of the longest track circuit.
2. The transmitter to be able to drive up to 2.0 amperes (minimum) into an impedance-matched loop.

E. Eight different train detection carrier frequencies to be used, with four frequencies dedicated for each track.

F. Frequencies used at tie-in locations to not conflict with the existing train detection carrier frequencies.

G. A minimum of four modulation rates to be required, and may be shared by both tracks.

H. Each track circuit will generate its own cab signal and train detection carrier frequency.

I. Each track circuit will be capable of transmitting a cab signal transmission carrier frequency of 4550-Hertz ± 25 Hertz.

J. Each track circuit to have the capability which permits each speed command transmission carrier code rate to be turned on and shut off, in a fail safe manner, by closing and opening a circuit or microprocessor vital output external to the track circuit.

K. At no time to a coded speed command transmission be transmitted to the rails during the shut off operation of this circuit.

L. Each track circuit to be capable of transmitting the following cab signal code rates as a square wave signal with equal on time and off time:

1. 50 codes per minute ± 4% for 6 mph
2. 75 codes per minute ± 4% for 15 mph.
3. 120 codes per minute ± 4% for 25 mph.
4. 180 codes per minute ± 4% for 35 mph.
5. 410 codes per minute ± 4% for 45 mph.
6. 270 codes per minute ± 4% for 55 mph.
7. 648 codes per minute ± 4% for 70 mph.

M. The cab signal code rate to be used to be selected via the code rate selection circuits, in a fail safe manner, by closing and opening a circuit or vital microprocessor external to the track circuit.

N. The train detection carrier frequency must be modulated at a code rate independent of the cab signal code rate. The train detection modulation rate will be set through use of a jumper on the module or through track circuit application programming.

O. Separate adjustments to be provided for the power levels of the track and train carrier frequencies.

P. The power level for the working circuit to not be more than eighty percent of the available power.

Q. The track circuit receiver filter to be a bandpass filter tuned to the train detection frequency.

R. The track circuit receiver filter to have the following characteristics:

1. At least 20 db down ± 8 percent of the train detection carrier frequency.
2. At least 60 db down for all train detection and speed command transmission carrier frequencies on the same track, including their harmonics frequencies, and their beat frequencies.
3. At least 45 db down for all train detection and speed command transmission carrier frequencies on the opposite track, including their harmonics frequencies, and their beat frequencies.

S. The filter to be of failsafe design. The shorting or opening of any element or component within the filter to either:

1. Not change the pass band, non-ringing, and attenuation characteristics of the filter.
2. Attenuate the output of the filter so that the associated track relay will drop or will remain down.

T. The receiver filter to not have adjustable elements.

U. The receiver amplifier gain to be adjustable.

V. All components in receiver section to be designed such that a failure of any component to cause a failsafe condition.

W. Code Demodulators:

1. The code demodulator to demodulate the carrier signal and to remove the code from it.
2. The code demodulator to have no adjustments.
3. For designs utilizing separate demodulation for the train detection, the receiver code rate to be selected by a non-changeable (one-time) set-up switch set to the transmitter modulation rate.

X. The audio frequency track circuit track relay to be a DC biased neutral relay that meets the requirements for vital relays as specified in the Relays Section of these Specifications.

Y. Drop away time of the track relay to not exceed 1.0 seconds from time of track shunt until back contacts make without a detected failure and shut down of the track circuit and to not exceed 1.8 seconds from time of track shunt until back contacts or the relay make under detected failure mode which will cause the track circuit to be shut down.

Z. Track circuit cables to be as specified in the External Signal Cable Section of these Specifications.

AA. Impedance bonds to be as specified in the Impedance Bond Layouts Section of these Specifications and to be produced by the same manufacturer as the audio frequency equipment manufacturer.

2.03 COMMAND TRANSMISSION LOOPS

A. Command loop transmitters to be in accordance with the track circuit transmitter requirements described within this Section.

B. Loop Turn-on:

1. Audio loops will be turned on in advance of a train entering the loop when a permissive signal aspect governing the track segment of the loop is displayed.

C. Matching Transformers:

1. Loop matching transformers, where required, to be rack mounted type, mounted within the relay house, room or tower and to not be mounted on ties or between the rails.

2. All loop impedance matching transformers, if required, to be identical.

D. Loop Cable:

1. External cable for the command transmission loops to be No. 9 AWG stranded copper insulated conductors in accordance with the External Signal Cable Section of these Specifications.
2. External cable from the house, room, or tower to the loop junction box to be No. 14 AWG.
3. The loop junction box to be in accordance with the Junction Boxes Section of these Specifications.

E. Clips and Fasteners:

1. Retainer clips to fasten the loop cable and hose to the rail to be plated spring steel fasteners with a mild steel strap, Erico Type SBA252S, or approved equal.

F. Conduits:

1. Conduit for protection of the loop cable leads to be FRE conduit in accordance with these Specifications.

2.04 RECEIVE ONLY/B-POINTS

A. Receivers to be in accordance with the track circuit receiver requirements described within this Section.

B. Multi-conductor Wire Loops:

1. If required by the manufacturer's design, to be enclosed in protective plastic conduit. Loop connector terminals to be enclosed and accessible.
2. Loops to be provided complete with all mounting hardware.

C. Relays:

1. To be DC biased vital type, in accordance with the Relays Section of these Specifications.

PART 3 - EXECUTION

3.01 IN-SERVICE COMPATIBILITY ACCEPTANCE TEST

A. Equipment of a type that is not currently in service on the CTA rail system to be required to successfully complete a minimum nine-month in-service acceptance test prior to submittal for acceptance for use in the Permanent train control system. This acceptance test to document complete compatibility with the existing CTA carborne system and traction power system, and to not interfere with signal systems on adjacent

tracks. Failure of insulated joints separating this equipment from existing systems to not result in an unsafe condition.

1. The acceptance test to document track circuit immunity from radiated signals generated by the CTA vehicle propulsion systems.
2. The acceptance test to document track circuit immunity from radiated signals generated by CTA's 6 pulse and 12 pulse traction power rectification systems.

B. This acceptance test to consist of a minimum of two complete, adjacent track circuits with all associated equipment, provided on an existing section of the CTA chosen by the Authority for test purposes.

3.02 INSTALLATION

A. Track Circuits:

1. Audio frequency track circuit modules and track relays to be rack mounted in accordance with the approved installation drawings.
2. Track circuits will be adjusted to 0.25Ω shunt sensitivity. The track circuit will be adjusted to de-energize with a 0.25Ω shunt strap placed across the rails within 5 ft. of the rail connections to the receive impedance bond.
3. Adjustment of track circuits to only be conducted under nominal operating conditions with all rail bonds, negative tap connections, and impedance bond rail connections installed and in good condition.

B. Loops:

1. Audio frequency transmission loops to be installed in accordance with the approved installation drawings.
2. The exact layout of the loop or loops through the special trackwork to be determined by the Contractor. Detailed drawings of the loop routing through special trackwork areas must be provided for review and approval in the drawing set.
3. Loops to be transposed to minimize coupling to the track circuits.
    a. Each loop to contain an odd number of transpositions to create an even number of loop sections.
4. Wires and conduit for the loops to be installed straight and parallel between transpositions, and to be firmly secured.
5. All loops to terminate within a loop junction box or wayside case.
6. Wire leads between a loop junction box or wayside case and the relay house or room to be twisted to minimize induction radiation, and to be contained within FRE conduit.

C. As required in specification 34 42 90, Technical Support, all Line Replaceable Units (LRUs) defined as the lowest level of equipment that may be replaced in the field to be barcoded with a unique code.

3.03 FUTURE CAPABILITIES DEMONSTRATION

A. The future capabilities demonstration to consist of a minimum of one complete track circuit with all associated equipment.

B. The Contractor to provide car carried test fixtures and prototype carborne systems to demonstrate and prove track circuit system future capabilities described in 34 42 20.A.2.

C. The CTA to provide a pair of 5000 series vehicles for use during the demonstration.

D. The wayside equipment required for the demonstration to be installed on non-revenue track at a location designated by CTA.

1. Track Access Occurrences will not be charged for testing on non-revenue track.

E. The demonstration to be successfully complete with all documentation accepted by CTA prior to Substantial Completion.

F. The future capabilities demonstration to be performed independently of the in-service compatibility acceptance test described in Part 3 A.

G. This demonstration and the associated documentation to be provided by the Contractor at no additional cost to this contract.

3.04 TESTS

Tests to be performed in accordance with the Signal System Tests Section of these Specifications.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The work of AUDIO FREQUENCY TRACK CIRCUITS shall not be measured for payment.

4.02 PAYMENT

A. No separate payment shall be made for the work covered in this section. Payment for the Work of AUDIO FREQUENCY TRACK CIRCUITS shall be included in the contract lump sum price as shown in the Schedule of Prices for SIGNAL AND TRAIN CONTROL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

B. Signal and Train Control Work: 344200

END OF SECTION

SECTION 34 42 23
IMPEDANCE BOND LAYOUTS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Requirements for furnishing and installing impedance bond layouts:

a. In areas of ballasted track.
b. On the elevated structure.
c. For use with existing ATP modules and system components.
d. For use with new ATP modules and system components.

B. Related Sections:

1. 34 21 25 Traction Power Cables.
2. 01 11 00 Summary of Work.
3. 34 42 01 Basic Signal System Technical Requirements.
4. 34 42 04 Signal System Drawing Requirements.
5. 34 42 20 Audio Frequency Track Circuits.
6. 34 42 40 External Signal Cable.
7. 34 42 91 Signal System Tests.
8. Division 5 Metals (sections as applicable).

1.02 SUBMITTALS

A. Before ordering, fabricating, or assembling equipment, submit the following for approval by the Authority:

1. Product Data:

a. Electrical characteristics including the DC rated propulsion current level
b. Physical dimensions including mounting bolt sizes, bond J-bar dimensions and lug sizes, and specific weight of impedance bond.
c. Environmental operating characteristics of the impedance bond including water resistance rating and temperature rating. All temperature effects on operation to be clearly indicated.
d. Factory test procedure and completed forms including frequency sweep information.

e. Test results of impedance bond functioning properly with a traction power imbalance current of 400 Amperes between each of the ears of the bond.
f. Method of separation of dissimilar metals.
g. Application, Installation, and Maintenance Manuals.

B. Prior to installation the Contractor to submit details of the following impedance bond layouts to the Authority for approval:

1. Shop Drawings:

a. Detailed installation for mounting outside of tracks in ballast at:

i. Interlockings.
ii. Station Platforms.
iii. Along the wayside
iv. Complete details of pedestals, vibration dampening, support hangers, mounting hardware etc. proposed for use on above ballast applications.

b. Detailed installation for mounting outside of tracks on elevated structures at:

i. Interlockings.
ii. Station Platforms.
iii. Along the wayside.
iv. Under walkways. (requires prior approval)
v. Complete scaled details of platform structures, vibration dampening, support hangers, mounting hardware, etc. for use on the above listed elevated structure applications.
vi. Modifications required to the structure to mount the platforms.
vii. Modifications required to the walkway to mount the impedance bonds. (requires prior approval)

c. Detailed installation for mounting outside of tracks in closed deck areas at:

i. Interlockings.
ii. Station Platforms.
iii. Along the wayside.

iv. Complete scaled details of support brackets, vibration dampening, mounting hardware, etc. for use on the above listed closed deck applications.

2. Cable layout drawings detailing cable runs and connections:

a. Impedance bond track winding terminals to rails.
b. Impedance bond with no center tap connection.
c. Impedance bond with center tap connection to Auxiliary Negative Return (ANR) rail.

i. For cross bonding and interlocking negative return.

d. Impedance bond with center tap connection to bond on opposite track.
e. Double impedance bond location adjacent to IJ.

3. The manufacturer's Quality Conformance Tests performed and results of additional water tightness testing.

C. Product data for the high-conductivity corrosion inhibiting grease including chemical makeup, MSDS, and anti-corrosion and conductivity properties.

D. Prior to safety verification testing submit Factory and Field Installation and Operation Test Procedures.

1.03 QUALITY ASSURANCE

A. Impedance bonds to meet the requirements of AREMA Signal Manual Part 8.4.5 where the requirements of the AREMA Recommendations do not conflict with any requirement specified within these Specifications.

B. As part of the Factory Test Procedures, the Contractor to perform a waterproofing test to assure that the impedance bond casing is watertight.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Impedance bonds to be properly crated to prevent damage throughout delivery storage and handling.

PART 2 - PRODUCTS

2.01 IMPEDANCE BOND GENERAL REQUIREMENTS

A. The track winding of each impedance bond to be rated to carry 2000 amperes per rail continuously. Intermittent rating to be three times the continuous rating.

1. The impedance bond to function properly with a traction current imbalance of up to at least 20 percent.

2. The DC resistance of the impedance bond, from track lug to track lug, to not exceed 0.00003 ohms.

B. Two track winding terminal lugs to be provided on each impedance bond.

1. Each track-winding lug to be designed to accept 1000 kcmil cables.

C. One center tap terminal lug to be provided on each impedance bond.

1. The center tap lug to be designed to accept up to four 1000 kcmil cables or up to three 2000 kcmil cables.

D. All impedance bonds to be provided with a name plate stamped with the following information with weatherproof labeling:

1. Manufacturer Name
2. Part Number
3. Serial Number
4. Tuned Operating Frequencies
5. Nominal Impedance Value at each of the Operating Frequencies
6. DC Propulsion Current Rating
7. DC Resistance Rating

E. The center tap on the impedance bond will be required to terminate:

1. Cross bonding cables.
2. A neutral cable to another impedance bond on the same track at insulated joints.
3. DC negative returns.
4. A copper extension plate and detailed layout to be provided for each impedance bond center tap requiring more than 2 negative return cable connections.

    a. Extension plates to be of sufficient size to accommodate all of the terminations required, and for the maximum current that may be encountered.
    b. Return connections to be included within the Contractor's block layout design.

F. The size of the impedance bond to permit ballasted mounting, direct fixation to a concrete deck and platform mounting on the elevated structures.

G. The impedance bonds to weigh less than 50 pounds each.

H. The size of the impedance bonds to not preclude any future relocation of the bonds to the center mounting on the ties at least one half inch below the plane of the top of the rails.

I. A water tight plug connector to be provided at the impedance bond to provide access for the twisted pair cable. Watertight plug connectors to also be provided for access for cables to the tuning unit, if required.

J. Cables for connections to rails and for cross bonds to be in accordance with the External Cable Section of these Specifications.

K. Impedance bonds to have a watertight cover.

L. Impedance bonds to be designed with four mounting bolts to properly install the bond on a mounting pedestal or bracket.

M. The impedance bond to be arranged for mounting as described below .

1. On the ballasted area pedestal foundation mounting plates.
2. On the elevated structure platforms.
3. Directly fastened to a concrete deck or vertically mounted on a sound wall in closed deck areas.

N. A one-half inch rubber pad to be installed between the impedance bond and the plate to which bond will be mounted. This pad is used as a means to minimize vibration.

1. Pad to be sized to cover bottom of impedance bond completely.
2. Bond mounting bolts and mounting plate fabrication to allow for pad thickness.

2.02 IMPEDANCE BOND LAYOUTS - GENERAL

A. Furnish and install impedance bonds at all locations according to the approved block designs

B. For impedance bonds located in ballast areas including the elevated ballasted territory north of Leland/Broadway, bonds to be installed according to the following conventions:

1. On platforms adjacent to the elevated ballasted structure.
2. On partially-buried steel pedestals adjacent to the tracks.
3. Within the gauge of rail at locations where it has been determined that the bond cannot be installed adjacent to the track.

C. For impedance bonds located on elevated structure locations, bonds to be installed according to the following conventions:

1. On steel platforms provided by the Contractor.
2. Underneath the foot walk.

3. Within the gauge of rail at locations where it has been determined that the bond cannot be installed adjacent to the track.

D. For impedance bonds located on in closed deck areas, bonds to be installed according to the following conventions:

1. On brackets fastened directly to the concrete deck.
2. Vertically on the sound wall.
3. Within the gauge of rail at locations where it has been determined that the bond cannot be installed adjacent to the track.

E. Side protection boards as described in the Miscellaneous Components and Products Section of these Specifications to be provided at each location where the impedance bond is on the same side of the tracks as the contact rail.

2.03 IMPEDANCE BOND LAYOUTS - BALLAST

A. Impedance bond layouts for installation in ballast to be provided complete with all mounting hardware and connections for mounting to pedestal foundations.

B. Pedestal foundations to conform to the following:

1. Pedestal foundations to be fabricated for varying depths of ballast:

   a. Long pedestal foundations, four feet in length (depth) to be used for burial in normal ballast wayside applications.
   b. Short pedestal foundations, two feet in length (depth) or less to have oversized bottom bases and used at locations with toow ballast such as bridge decks.

2. Top of pedestal used for impedance bond mounting to be adjustable to maintain levelness of the bond.
3. Fabrication to be such that impedance bond can be easily removed and reinstalled without obstructions and without disturbing pedestal leveler adjustments.

C. Design and installation of the impedance bond foundation pedestals is subject to approval by the Authority.

D. Pedestals to conform to Division 5 –Metals, of these Specifications.

2.04 IMPEDANCE BOND LAYOUTS – STRUCTURE

A. Impedance bond layouts for installation on platforms to be provided complete with all structure mounting hardware, and hardware and connections for mounting impedance bonds to the structure.

B. Platform construction to conform to the following:

1. Design to allow the bond to be serviced from either side, parallel to the tracks.
2. The impedance bond to be mounted a minimum of five feet ten inches from the centerline of any track. The tuning unit, where required, to be mounted parallel to the track next to the impedance bond.
3. Platforms to have a minimum of three feet of space adjacent to the left and right sides of the impedance bond and tuning unit parallel to the tracks. Platforms to have a minimum of six inches behind the impedance bond or tuning unit at the point furthest from the tracks.
4. Platforms to have room for a minimum of two maintainers and equipment to service the bond.
5. Platforms to be equipped with railings and kick plates.
6. Installation of the platforms to include installing 2" x 8" treated planking in between the running rails adjacent to the platform and between the closest running rail and the platform grating to form a walkway to the platform.
7. A flashboard to also be provided at locations where the platform is adjacent to the third rail.
8. Platform design to be adapted to suit field conditions as required. Distances from the centerline of track apply to tangent track only; these distances to be increased for platforms located on or near curves to allow for car body overhangs to maintain the minimum clearance.
9. Platforms to be designed to allow full access for the connection and maintenance of the impedance bonds.
10. Platforms to not be installed in the middle third of the span between the bents.

C. Design and installation of the impedance bond platforms is subject to approval by the Authority.

D. Platforms to conform to Division 5 –Metals, of these Specifications.

2.05 IMPEDANCE BOND LAYOUTS – CLOSED DECK

A. Impedance bond layouts for closed deck areas to be provided complete with all brackets, mounting hardware and connections for a complete installation.

B. Installation on concrete deck to conform to the following:

1. Design to allow the bond to be serviced from either side, parallel to the tracks.
2. The impedance bond to be mounted a minimum of five feet ten inches from the centerline of any track. The tuning unit, where required, to be mounted parallel to the track next to the impedance bond.

3. A flashboard to also be provided at locations where the impedance bond is adjacent to the third rail.
4. The installation to be adapted to suit field conditions as required. Distances from the centerline of track apply to tangent track only. These distances to be increased for platforms located on or near curves to allow for car body overhangs to maintain the minimum clearance.

C. Installation on the sound wall to conform to the following:

1. Design to allow the bond to be mounted vertically on the sound wall.
2. The impedance bond to be mounted a minimum of five feet ten inches from the centerline of any track.
3. Track leads to be installed underneath the concrete deck, passing through sleeves installed in the deck for that purpose.
4. Track leads to be securely fasted to the deck support structure with insulated cable clamps.
5. The installation to be adapted to suit field conditions as required. Distances from the centerline of track apply to tangent track only. These distances to be increased for platforms located on or near curves to allow for car body overhangs to maintain the minimum clearance.

D. Design and installation of the impedance bond in open deck areas is subject to approval by the Authority.

2.06 IMPEDANCE BOND LAYOUTS – UNDER WALKWAY (Requires CTA approval)

A. Under walkway impedance bond layouts to be provided for impedance bond locations on the elevated structure between tracks, where the installation of platforms is not practical, as approved by the Authority.

B. Strapping to be galvanized steel, sized as necessary to support the impedance bond.

C. All materials required for the layout to be provided by the Contractor, including replacement of the walkway in the impedance bond areas, and provision of side protection boards where contact rail is adjacent to installation.

2.07 IMPEDANCE BOND LAYOUTS – INSIDE RAIL GAUGE (requires Authority approval)

A. Where clearances are tight on both sides of the track or as designated by the the Authority, impedance bonds may be installed inside the gauge of rail.

B. All impedance bonds to be recessed between ties and mounted using a steel bracket.

C. All impedance bonds and tuner assemblies (if required) to be protected with a 12 gauge hot-dipped galvanized steel skid plate.

1. Contractor must ensure that impedance bond with skid plate is clear of the train bottom clearance.

D. All materials required for the layout to be provided by the Contractor.

2.08 COMPONENT ASSEMBLIES

A. The Contractor to verify that compatible metals are used throughout the assembly of all structures, fixtures and adjoining components including the fasteners. If contact between two dissimilar metals cannot be avoided, an isolator to be used between the two dissimilar metals thereby circumventing direct contact. The method of separation to be submitted to the Authority for approval.

2.09 IMPEDANCE BOND LAYOUTS – FOR USE WITH EXISTING ATP EQUIPMENT AND SYSTEMS

A. The Contractor to furnish and install impedance bond layouts that must function in conjunction with existing ATP systems and components.

1. Ansaldo AF-800 ATP system.
2. Ansaldo AF-500 ATP system.
3. Alstom (formerly General Railway Signal) 31049 ATP system, commonly referred to as “GRS-II” or “AFTC2”.

B. The impedance bonds furnished by the Contractor must be certified by the OEM of the existing ATP system hardware as being fully compatible and safe for use with their existing equipment.

C. The Authority will not provide impedance bond layouts for these installations. All bonds furnished and installed in conjunction with existing ATP equipment will be newly manufactured units. Installation of “Old-stock” equipment will not be allowed.

D. These impedance bonds to meet the requirements of the Contract Documents with the following exceptions:

1. The impedance bonds will not be of the universal type. Each will be tuned for specific train detection receive, train detection transmit and 4450Hz cab carrier frequencies.

PART 3 - EXECUTION

3.01 GENERAL INSTALLATION

A. The Contract Documents include plans calling out the intended installation location and type of support means required for each impedance bond layout. Installation between rails will not be allowed without written approval from the Authority.

1. Only those impedance bonds at approved locations to be mounted within the gauge of rail.

B. All cable connection lugs and impedance bond track terminal winding surfaces to be thoroughly cleaned with emery cloth. Immediately thereafter, the Contractor must apply a high-conductivity corrosion inhibiting grease (such as Sanchem Industries, Inc. “No-ox-id A-Special” or approved equal) on all electrical contact surfaces prior to fastening and tightening.

C. See the Rail Connection and Running Rail Bonding – Traction Power specification for details on bonding the impedance bond to the rail.

D. In general, the bond to be mounted on the right hand side of the tracks (normal direction of traffic).

E. Provisions to be made for impedance bonds for cross bonding substation return and elevated structure connections at a minimum of every 2000' feet.

F. Adjacent impedance bonds on the same track to not be cross bonded to impedance bonds on the adjacent track or to the structure.

G. A one-half inch thick rubber pad to be installed between the impedance bond and the plate to which bond will be mounted. This pad is used as a means to minimize vibration.

1. Pad to be sized to cover bottom of impedance bond completely.
2. Bond mounting bolts and mounting plate fabrication to allow for pad thickness.
3. Tuning units (if required) to be equipped with the same type of vibration dampening.

H. As required in the Technical Support specification, all Line Replaceable Units (LRUs) defined as the lowest level of equipment that may be replaced in the field to be barcoded with a unique code.

3.02 INSTALLATION ON BALLAST

A. Impedance bond layouts for the ballasted areas to be installed on pedestals with a minimum clearance of 7’-2” from the centerline of track to the center tap of impedance bond whenever possible. Where insufficient clearance exists between the structural wall parapet and tracks N1 and N4, impedance bond layouts will be installed on steel platforms which cantilever away from the walls.

B. Impedance bond layout height to be such that base of impedance bond is level with or just slightly above top of tie.

C. In general, the bonds to be mounted according to the following (with respect to the normal direction of traffic):

1. Bonds on track N1 will be installed to the right (west) of the track.

2. Bonds on track N2 and N3 will be installed between those tracks.
3. Bonds on track N4 will be installed to the right (east) of the track.

3.03 INSTALLATION ON CLOSED DECK

A. Impedance bond layouts for the closed deck areas to be installed vertically in voids in the sound wall left open for that purpose or on brackets mounted directly to the concrete deck in areas where there is no sound wall. Maintain a minimum clearance of 7’-2” from the centerline of track to the center tap of impedance bond whenever possible.

B. Impedance bond layout height to be such that base of impedance bond is level with or just slightly above top of tie.

3.04 INSTALLATION ON ELEVATED STRUCTURES

A. Impedance bond layouts earmarked for installation on tracks N1 and N4 in elevated structure territory to be installed on cantilevered steel platforms adjacent to the respective track.

B. Impedance bond to be mounted on a rubber padded base at platform deck height with center tap a minimum of 5’8” from center of track.

C. Impedance bond layouts earmarked for installation on tracks N2 and N3 in elevated structure territory to be installed under the elevated foot walk or between the gauge of rail, as approved by CTA.

3.05 CABLE AND WIRE

A. Twisted pair train detection cable between the impedance bond secondary windings and signal houses/rooms or local junction boxes to be provided in accordance with the External Signal Cable Section of these Specifications.

B. Cable connecting to impedance bond track winding and center tap terminals to be in accordance with the Traction Power Cable Section of these Specifications.

3.06 TESTS

A. The Contractor to test the impedance bonds in accordance with the approved installation and operating test procedure.

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The work of IMPEDANCE BOND LAYOUTS shall not be measured for payment.

4.02 PAYMENT

A. No separate payment shall be made for the work covered in this section. Payment for the Work of IMPEDANCE BOND LAYOUTS shall be included in the contract lump sum price as shown in the Schedule of Prices for SIGNAL AND TRAIN CONTROL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

B. Signal and Train Control Work: 344200

END OF SECTION

SECTION 34 42 25
RAIL CONNECTIONS AND RUNNING RAIL BONDING SIGNAL

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. The work to be done under this Section consists of furnishing and installing rail connections and running rail bonding.

B. Related Sections:

1. 34 42 40 External Signal Cable.
2. 34 42 91 Signal System Tests.

1.02 REFERENCES

A. American Railway Engineering and Maintenance-of-Way Association (AREMA).

1. AREMA Communications and Signals Manual of Recommended Practice (C&S Manual) Part 8.

1.03 SUBMITTALS

A. The Contractor to submit the following plans and information for approval by the Authority:

1. Product Data:

a. Signal bonds and weld material including material composition, electrical, and mechanical characteristics.
b. Molds to be used for exothermic welds.
c. Non-toxic cleaning solvent.
d. Grinding Disc to be used to grind the rail.
e. Manufacturer testing certification for conformance with AREMA C&S part 8.1.30 & 8.1.34.

2. Shop Drawings:

a. Drawings showing detailed final design for bonding special track work to assure that all pieces of special track work are properly connected electrically.

3. Procedures:

a. Field installation procedures for each type of welded connection.
b. Field Inspection and Testing Procedures for Rail Bonding.

1.04 QUALITY ASSURANCE

A. The Contractor to install each welded bond in accordance with the manufacturer's guidelines and the requirements of this Section. Each welded bond to be inspected and tested in accordance with the submitted inspection and testing procedure.

B. Exothermic welding to only be completed by individuals trained and certified by the bond manufacturer within the past 3-years. These individuals must provide proof of certification when requested by CTA.

C. The CTA reserves the right to conduct electrical testing on a random sampling of exothermic. Failure of these bonds to meet the required electrical properties as defined in AREMA 8.1.30, will require the contractor to to enlist the services of a testing firm to test all exothermic bonds and replace any that fail the electrical test.

D. Exothermic Welding Requirements:

1. It is required that each certified exothermic welder to weld, in the field, under conditions similar to those of the actual work area, not less than three exothermic rail connections.
2. Demonstrate as many additional welds as required by the Authority to determine the welds are being made satisfactorily.
3. Exothermic welds to be subject to inspection and test by the Authority and certification of the installer will depend on the results of these inspections and tests.
4. The final approval of the installers to be by the Authority.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Rail bonds to be manufacturers bonds prepared for welding by the exothermic process. Bonds, bonding materials and types of molds to be submitted to the Authority for review. Material to be compliant with C&S Manual Parts 8.1.30, 8.1.31 and 8.1.34.

1. Copper based exothermic weld material to comply with the requirements of the AREMA Communication and Signal Manual Part 8.1.34.
2. Proposed non-toxic solvent to remove grease and dirt from the rail after grinding to be submitted for approval.
3. All welding must be conducted in a dry environment. Welding during wet weather conditions is not allowed unless the area being welded is fully protected from the elements.

B. Running Rail Track Connections:

1. Material: Cadmium bronze.
2. Size: 3/16 inch by 7 inches.
3. Connection: Railhead, exothermic weld.
4. Install in accordance with C&S Manual Part 8.1.30.
5. Two bonds for each AC track circuit wire (each track wire plus one spare)
6. One bond for each end of an AC Track circuit jumper cable.
7. These bonds to be manufacturers bonds prepared for welding by the exothermic process. Bonds, bonding materials and types of molds to be submitted to the Authority for review.

C. Signal Rail Joint Bonds:

1. Material: Cadmium bronze.
2. Size: 3/16 inch by 7 inches.
3. Connection: Railhead, exothermic weld.
4. Install in accordance with C&S Manual Part 8.1.30.
5. One bond at each rail joint.
6. These bonds to be manufacturers bonds prepared for welding by the exothermic process. Bonds, bonding materials and types of molds to be submitted to the Authority for review.

D. Fouling Bonds:

1. Material: Cadmium bronze.
2. Size: Fouling bonds for special track work areas to be 3/16 inch for signal rail fouling cables
3. Connection: Railhead, exothermic weld.
4. Install in accordance with C&S Manual Part 8.1.30.
5. These bonds to be manufacturers bonds prepared for welding by the exothermic process. Bonds, bonding materials and types of molds to be submitted to the Authority for review.

E. Switch Heater Element Return Bonds:

1. Material: Cadmium bronze.
2. Size: 3/16 inch by 7 inches.
3. Connection: Railhead, exothermic weld.
4. Install in accordance with C&S Manual Part 8.1.30.
5. One bond for each heater element return wire.

6. These bonds to be manufacturers bonds prepared for welding by the exothermic process. Bonds, bonding materials and types of molds to be submitted to the Authority for review.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Exothermic Bonds:

1. For all rail joint and rail head bonds, the surfaces of the rails where the bond is to be applied to be ground clean with a reinforced grinding wheel, of a type as recommended by the bonding material manufacturer. The use of vitrified grinding wheels will not be allowed. After grinding, the surface to be cleaned with a manufacturer approved non-toxic solvent to remove all traces of grease and dirt.

B. Running Rail Track Connections:

1. Where single rail track circuits are used, the running rail track connections to be by 3/16 by 7 inch exothermic signal bonds.

C. Signal Running Rail Bonds:

1. Where single rail track circuits are used, the running rail joints in the signal rail to be bonded using 3/16 by 7 inch exothermic signal bonds.

D. Fouling Bonds:

1. Fouling bonds to be installed based on the approved signal drawings developed by the Contractor.
2. In areas where single rail track circuits are used, the signal rail to be bonded using 3/16 inch exothermic signal bonds.

E. Switch Heater Element Return Rail:

1. Switch heater element return connections to be by 3/16 by 7 inch exothermic signal bonds.

F. Removal of Existing Connections and Grounds:

1. The Contractor to be responsible for isolation of the double rail track circuits from any grounds and return connections. The Contractor to test the rail sections for isolation, and to remove all grounded connections, including any grounded track fasteners, tie fasteners, and tie plates within any rail section that are connected to ground or bonded to ground or another track circuit.
2. The Contractor to inspect and test track circuits where the existing rail is to remain for other rail connections, and to remove any existing abandoned connections. Connections between the existing rail and the supplemental return cables to be removed from the rail connection to the supplemental return cable. The supplemental return cable to be re-taped and insulated for 600 volt DC service.

3.02 TESTS

A. The Contractor to demonstrate that the bonding is in accordance with the requirements of this Section, as shown on the Contract Drawings, and as specified in AREMA Communication and Signal Manual Part 8.1.30, Part 8.1.31 and 8.1.34.

B. Any bond, weld, or connection installed by the Contractor which is found to be defective to be removed and a new bond to be installed a minimum of three inches away from the last bond at no additional cost to the CTA.

C. All required inspections and tests are to be included in the Field Inspection and Testing Procedures for Rail Connections and Rail Bonding submitted to the Authority. All rail connections and rail bonding must comply with the requirements of these inspection and test procedures.

PART 4 - MEASUREMENT AND PAYMENTMEASUREMENT

A. The work of RAIL CONNECTIONS AND RUNNUNG RAIL BONDING SIGNAL shall not be measured for payment.

4.02 PAYMENT

B. No separate payment shall be made for the work covered in this section. Payment for the Work of RAIL CONNECTIONS AND RUNNUNG RAIL BONDING SIGNAL shall be included in the contract lump sum price as shown in the Schedule of Prices for SIGNAL AND TRAIN CONTROL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

C. Signal and Train Control Work: 344200

END OF SECTION

SECTION 34 42 38
MISCELLANEOUS COMPONENTS AND PRODUCTS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Furnishing and installing miscellaneous components and products.

B. Related Sections:

1. 26 05 33 Raceways and Boxes.
2. 31 20 10 Earthwork for Underground Utilities.
3. 34 42 10 Signal System Ductbank.
4. 34 42 11 Power Switch-and-Lock Movement Layouts.
5. 34 42 12 Electric Lock and Hand Operated Switch Layouts.
6. 34 42 14 Concrete Foundations.
7. 34 42 25 Instrument Racks.
8. 34 42 36 Entrance Racks.
9. 34 42 40 External Signal Cable.
10. 34 42 41 Internal Wire and Cable.
11. 34 42 42 Signal DTS Cable.
12. 34 42 50 Snowmelter Layouts.
13. 34 42 51 Snowmelter Control Cases.
14. 34 42 60 Relay Houses.
15. 34 42 61 Relay Rooms.
16. 34 42 62 Junction Boxes.
17. 34 42 64 Relay Cases.

1.02 REFERENCE STANDARDS

A. Section incorporates by reference the latest revisions of the following documents (unless otherwise noted), or if standard is adopted by the Authority Having Jurisdiction, the latest revision adopted:

B. American Railway Engineering and Maintenance-of-Way Association (AREMA).

1. AREMA Communications & Signals Manual of Recommended Practices (C&S Manual).

C. United States Department of Agriculture, Rural Development (USDA RD).

1. USDA RD Bulletin 345-83 (PE-80), Specification for Gas Tube Surge Arresters.

D. American National Standards Institute (ANSI), Institute of Electrical and Electronic Engineers (IEEE).

1. ANSI/IEEE Standard C.62.41.2 – 2002 Recommended Practice on Characterization of Surges in Low Voltage (1000V and less) AC Power Circuits.

1.03 SUBMITTALS

A. The Contractor to submit the following plans and information for approval by the Authority:

1. A description of material to be furnished under this Contract.
2. Certificates of conformance for all materials provided under this Contract.

B. Product Data:

1. Each type of component or product proposed.

C. Samples:

1. Submit one of each type of proposed solderless terminal.

D. Closeout Submittals

1. Submit a general maintenance manual to permit future direct ordering of miscellaneous components by the Authority.
2. Manual to include catalog cuts, data sheets, and manufacturer's part numbers.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Electrical components:

1. Rated to operate at power, voltage, current, and temperature levels exceeding by 20 percent those that the components will be subject to in service, unless otherwise specified.

2.02 CIRCUIT BREAKERS, FUSES AND FUSE CLIPS

A. Fuses and circuit breakers to be of suitable capacities to protect the various pieces of signal apparatus from the effects of short circuits or overloads.

B. All circuit breakers and fuses required for the equipment and systems to be in accordance with these Specifications.

C. The Contractor to provide fuses for all equipment as required to provide circuit protection as defined within the Contract Documents, and in accordance with the National Electrical Code.

D. Fuses to be controlled time delay, current limiting, non-indicating and non-renewable.

1. Low Voltage Fuses - For 110 volt circuits or less that are not connected to the rails or contained within snowmelter enclosures, fuses to be 250V AC, Class RK1 with interrupt ratings of 200kA AC and 20kA DC, manufactured by Cooper-Bussman, catalog number KWN-R or approved equal.
2. High Voltage Fuses - For protection of snowmelter heaters to be 1000V DC with an interrupt rating of 100kA DC, manufactured by Ferraz Shawmut, catalog number gRB or approved equal. For AC track circuits, house and room heaters, and other connections to the rails, fuses to be 600V AC/DC rated, Class RK1, dual-element, current limiting/time-delay with interrupt ratings of 300kA AC and 100kA DC, manufactured by Cooper-Bussman, catalog number LPS-RKxSP or approved equal.
3. In applications where a snowmelter heater's return is bonded to the signal rail of an AC track circuit, the Contractor will coordinate the ratings of both heater branch circuit and AC track circuit (track-side) fuses such that, in the case of a heater fault to signal rail, the heater branch circuit fuse will clear/open prior to clearing of the AC track circuit fuse.

E. AC fuse blocks to be Phenolic base, 2 pole, Class R, center barrier, pressure terminals, rated 250V or 600V AC (based on application), 0-30 amperes, Underwriters Safety Device - Cat. No. R25030 - 2 PR.

F. DC fuse blocks to be Phenolic base, 1 pole, Class R, mainline side barriers, box type terminals, rated 1000V DC. 0 to 30 amperes or 31 to 60 amps, with reinforcing springs, Underwriters Safety Device - Cat. No. R60030-1-CR or H60060-1-CR.

2.03 CONDUIT

A. Galvanized rigid steel conduit:

1. Comply with requirements of the Raceways and Boxes Section of these Specifications.

B. Reinforced Thermosetting Resin Conduit (Type RTRC):

1. Comply with requirements of the Raceways and Boxes Section of these Specifications.

C. Liquidtight flexible metal conduit (Type LFMC):

1. Comply with requirements of the Raceways and Boxes Section of these Specifications.

D. Cable entrance pipes for relay houses, relay rooms, towers, wayside cases, and junction boxes to be four inch minimum RTRC, and to be as furnished complete with one holding device and one bell end bushing for each such pipe as shown in these Contract Documents.

E. One spare entrance pipe assembly to be furnished for each enclosure.

F. Flexible hose:

1. Braided Cordura rayon, vari-purpose hose, internal tube neoprene cover, or approved equal.
2. Hose clamps:

   a. Worm-drive stainless steel.

3. Fittings:

   a. Compression
   b. Watertight.

2.04 DIODES

A. All diodes to be furnished under this Contract to carry a JEDEC number or to be available from more than one manufacturer and to be used within the published specifications for such number.

B. All diodes to be silicon type, unless otherwise approved by the Authority.

2.05 ENVIRONMENTAL PROTECTION

A. Corrosion prevention compound:

1. Product must have sufficient body to resist weather and rusting for at least six months.

B. Approved Manufacturer/Product:

1. Sanchem, Inc.
2. NO-OX-ID.
3. Or approved equal.

2.06 FIBERGLASS FOOTWALK

A. All footwall, platform grating, railings, and signposts to be fiberglass.

B. The fiberglass to be fabricated with continuous strand roving mat reinforced, thermoset unsaturated polyester electrical insulating laminate produced by the pultrusion process with a UV inhibitor.

C. Fiberglass material to meet the following:

PROPERTIES	TEST	GRATINGS	RAILINGS
FLEX. STRGTH., PSI	ASTM D-790	25,000 MIN.	30,000 MIN.
FLEX. MOD., PSI	ASTM D-70-	1.0 MIN.	2.0MIN.
TENSL. STRGTH., PSI	ASTM D-638	17,000 MIN	30,000 MIN.
TENSL. MOD., PSI (10^5)	ASTM D-638	9.0 MIN.	8.0 MIN.
IMP. STRGTH., FT-LB/IN.	ASTM D-256	25 MIN.	
PERP. DIELECT. (VPM)	ASTM D-149	170 MIN.	200 MIN.
ARC RES. (SEC)	ASTM D-495	180 MIN.	120 MIN.
WATER ABS. (%)	ASTM D-570	0.2 MAX.	0.8 MAX.
THERM. EXP. (IN/IN/F)		$7X10^{-6}$ MAX.	$5.2X10^{-6}$ MAX.
FLAME SPREAD	ASTM E-162	60 MAX.	
FLAME RESIST.	UL 94	V-O MIN.	V-O MIN.
TRKING RESIST. (MIN.)	ASTM D-2303	600@ 2500V	
SPEC. OPTIC. SMOKE DENS.	ASTM E-662	200 MAX.	

D. Standard grating panels to be two inches thick, 30 inches wide, with a 50% open surface.

E. Color to be gray.

2.07 HARDWARE

A. All mounting hardware exposed to the elements and used for signal equipment, cases, conduit, hangers, brackets, clamps, etc., to be hot-dip galvanized, except as otherwise approved by the Authority.

1. Galvanizing:

a. The hot dip process of galvanizing to be used.
b. All parts to be pickled so that all scale and adhering impurities will be removed.

c. The zinc coating to be of commercially pure zinc, and to be continuous and thorough.
d. It to not scale or blister or be removable by any of the processes of handling or installation.
e. The finished surface to be free from fine line cracks, holes, or other indications of faulty galvanizing.
f. It to be smooth and free from adhering flux and other impurities.
g. The edges and ends of parts to be free from lumps and globules.
h. Parts to be coated with at least two ounces of zinc per square foot of galvanized surface, after all bending, cutting, drilling, and final fabrication.
i. In order to avoid destruction of resilience encountered in the hot dip process of galvanizing, all lock-washers to be cadmium plated.

B. Cadmium Plating

1. All nuts, bolts, and washers used for the mounting of equipment within finished enclosures to be cadmium plated or stainless steel.
2. As an alternate, the Contractor may submit another type of plating or non-corroding metal for the Authority's approval.
3. Cadmium plating to be an impervious, dense, hard, fine grained, continuous, closely adhering coating of commercially pure cadmium, free from capillaries and to completely cover the surface of the part in a smooth, bright layer.
4. Plating on raised or prominent portions to show no evidence of blackness or loose crystalline structure.
5. It to have a minimum thickness of 0.0006 inches and to withstand the salt spray test for at least 1000 hours or an equivalent test approved by the Authority.

2.08 IDENTIIFICATION OF CABLE, WIRE AND EQUIPMENT

A. Permanently identify the following with a tag:

1. Both ends of each cable and each cable wire and all single wires that terminate in:

a. Relay houses.
b. Relay rooms.
c. Towers.
d. Relay cases.
e. Junction boxes.
f. Signals.
g. Train stops.

h. Snowmelter cases.
i. Switch mechanisms.
j. Control panels.
k. Route selectors
l. Any signal system equipment not explicitly noted above.

B. Tags to not obscure connecting links used between terminal binding posts.

C. Tags to be installed such that the tag material is not pressed between layers of the standard AAR hardware schedules.

D. Tags to be installed so that they may be read with a minimum of disturbance of the tags and wiring.

E. Each conductor of the cable to be rung out and identified before applying the tag.

F. The lettering on all tags to be mechanically typed, waterproofed and permanent. The tags to bear the following information in the sequence listed:

1. Wire nomenclature.
2. Cable designation (if applicable).
3. Termination point (rack no., row and contact no., if applicable).
4. Termination point of other end of wire.

G. Tags for wire identification to be waterproof, sleeve type tags.

H. Entrance Rack or Main Terminal Board terminals to be tagged with waterproof, flat type tags securely fastened to the front of the board. Provide two fasteners per tag, one to the left and another to the right. Fasteners to be stainless steel brads with ring-shanks or staples.

I. Each cable to be tagged at its point of entry into relay houses, wayside junction boxes and relay cases.

J. Cable tags will be 1-1/2 inches in diameter with a 1/4 inch hole to accept cable ties. Nomenclature will be mechanically printed on 10 mil solid base nylon film material with a yellow base color. Following printing, each tag will be covered with a clear film coating with a thickness of 5 mils. Font will be Arial, 12 point minimum.

K. Cable tags will include the following information printed from top to bottom:

1. Cable identification number (“CK1,” “C5,” etc.) based on the Contractor’s final design.
2. Cable type including number of conductors and conductor size (e.g. “12C#14”)
3. Destination of cable

L. The 1/4 inch mounting hole for all cable tags to be drilled at the 9-o'clock position. Text to be printed such that when the tag is lashed to the vertical cable, the text is readable in a top to bottom fashion. Where cables are grouped such that tags on adjacent cables will overlap, offset adjacent cable tags vertically so that all text among adjacent tags is readable and not obscured. Cable tags to be attached to each cable no less than 16" above the interior surface of the relay house, junction box or relay case floor.

M. Cable tags to be Twinco Manufacturing P/N 51-003-6-D or approved equal.

N. Cable tags will be attached to each cable with a nylon cable tie, color black, of sufficient length to surround the cable jacket perimeter and provide full engagement with the locking head. Following installation, excess cable tie material will be cut back and removed.

2.09 RE-TAGGING OF EXISTING WIRING

B. Where existing internal or external conductors change nomenclature due to repurposing, the Contractor will remove all existing tags from all conductors that are part of the complete circuit. The Contractor will then provide new wire tags for each conductor that is part of the newly configured circuit including all parallel branches. Re-tagging will be required in the following instances:

1. An existing, unused or spare conductor is assigned with a new, active function.
2. An existing, used conductor is retired and becomes an unused or spare.
3. An existing, used conductor is reused and the existing nomenclature requires modification due to modification of the circuit of which it is part.

B. Where wires and cable conductors require re-tagging, the Contractor will provide new rectangular tags which conform to the following:

1. Nomenclature will be mechanically printed on 10 mil solid base nylon film material with a white base color. Following printing, each tag will be covered with a clear film coating with a thickness of 5 mils. Font will be Arial, 12 point minimum.
2. Tags will be 7/8 inches wide by 1-1/2 inches tall with a factory-drilled 5/16" diameter hole provided at the top of the tag.
3. Tags will be printed with the wire/conductor nomenclature as follows:

    a. First Line: Cable ID and conductor numbers (i.e. C110W15).
    b. Second Line: Circuit nomenclature
    c. Third Line: (local) Point where the wire is terminated.
    d. Fourth Line: Point where the remote end of the wire or cable conductor is terminated.

e. For wires contained within a house, case or room, the information in item “a” above will be omitted and the tag will have only three lines of text.

4. Tags will be Twinco Manufacturing RD-style flat tags or approved equal.
5. Replacement tags will be affixed to wires and cable conductors using 3 inch long nylon cable ties with a width of 0.09 inches, color black. Following installation, the excess cable tie will be cut back.

2.10 LIGHTNING ARRESTERS AND EQUALIZERS

A. Comply with AREMA C&S Manual 11.3.1, Recommended Design Criteria and Functional/Operating Guidelines for Primary Surge Protection of Signal Systems.

B. Base:

1. Three-post porcelain type or other approved type.

C. Gas Tube Arrester for Signal Circuits:

1. Construction:

a. Ceramic metal.
b. Provided with ring terminals.
c. Lead insulation.
d. For mounting on signal terminal blocks.

2. Arrester to meet or exceed the following:

a. Typical DC breakdown voltage:

i 145 V at 500 V/second.

b. Minimum DC breakdown voltage:

i 116 V at 500 V/second.

c. Maximum DC breakdown voltage:

i 1174 V at 500 V/second.

d. Impulse breakdown:

i 500 V @ 100 V/microsecond.

e. Arc Voltage:

i 15 V with an arc current of 5 A.

f. Capacitance:

i Maximum 1 pF.

g. Surge life:

i 1000 minimum at 500 A (10x1000 microseconds).

h. Maximum current surge:

i 20 kA (8 x 20 microseconds).

i. Ac current:

i 20 A (10 x 1 second at 60 Hz).

j. Ac follow-on current:

i 20 A peak (1/2 cycle at 60 Hz).

k. DC holdover voltage:

i Typical 90 V per REA PE-80, 0.2A.

D. Transient Voltage Suppressor for Signal Circuits:

1. Provide with ring terminals and lead insulation for mounting on signal terminal blocks.
2. Suppressor to meet or exceed the following:

a. Reverse stand-off voltage:

i 16 VDC.

b. Energy handling capacity:

i 5 J (5000 W for 1 ms).

c. Voltage range to initiate 5 mA DC conduction:

i 17.8 to 19.7 VDC.

d. Maximum peak pulse current:

i 192 A (10 x 1000 microsecond waveform).

e. Maximum DC clamping voltage at peak pulse current:

i 26 V peak.

f. Line-to-line secondary:

i Tertiary level protection for a nominal 12 VDC source.

E. Metal Oxide Varistor (MOV) for Signal Circuits:

1. Provide with ring terminals and lead insulation for mounting on signal terminal blocks.
2. MOV to meet or exceed the following:

a. Maximum continuous applied DC voltage:

i 30 VDC.

b. Maximum continuous applied ac voltage:

i 23 V rms.

c. 1 mA DC conduction voltage range:

i 32 to 40 VDC.

d. Peak current handling capacity:

i 2000 A (8 x 20 microsecond waveform).

e. Energy handling capacity:

i 160 J.

f. Typical capacitance:

i 12,000 pF.

g. Maximum clamping voltage:

i 63 V peak at a device current of 20 A.

F. Gas Tube Lightning Arresters for Data Communication System:

1. Type:

a. Two electrode screw-in.
b. Rated heavy duty.
c. UL listed for use on terminal blocks provided under this Contract.

2. Arresters to be, as per USDA RD Bulletin 345-83 (REA PE 80).

2.11 PADLOCKS AND KEYS

A. Adlake type switch locks:

1. Zinc plated steel locks with brass keys.
2. Acceptable Manufacturer/Product: Adams & Westlake, switch locks and keys.

B. Barrel locks:

1. Raco type hexagon spanner locks complete with 13-1/2 inch bronze chain and mounting hardware.

2.12 PAINT AND FINISH

A. Comply with applicable recommendations in AREMA C&S Manual 1.5.10, Recommended Instructions for Painting and Protective Coatings, where AREMA recommendations do not conflict with requirement of these Specifications.

2.13 RESISTORS

A. All resistors, other than those required for electronic circuits, to be in accordance with AREMA Signal Manual Part 14.2.15.

2.14 SEALING COMPOUND

A. Comply with AREMA C&S Manual 15.2.15, Recommended Functional Guidelines for Cold Application Sealing Compound.

2.15 SIDE PROTECTION BOARDS:

A. Material:

1. Fiberglass square tube.

B. Dimensions:

1. 2 inches by 8 inches.

C. Acceptable Manufacturer/Product:

1. Creative Pultrusions, Inc.

a. Series 1525.

2. Or approved equal.

D. Fastening Hardware:

1. Stainless steel bolts, nuts, and washers.
2. Galvanized lag screws.

E. Supports:

1. 1/2-inch by 2-inch galvanized steel bar, bent before galvanizing.

F. Anchors:

1. Epoxy type.

2.16 SIGNAL TERMINAL BINDING POSTS

A. Binding posts, other than those required for supervisory control circuits and control panels, to be in accordance with AREMA C&S Manual 14.1.10, Recommended Criteria for Binding Posts.

2.17 SIGNAL TERMINAL BLOCKS

A. Comply with applicable requirements of AREMA C&S Manual 14.1.5, Recommended Criteria for Molded Terminal Blocks.

2.18 TRAIN CONTROL SIGNAGE (REFER TO SECTION 34 10 14)

2.19 STAINLESS STEEL CLAMPS

A. Clamps for clamping hose at each end to be of the worm-drive stainless steel type.

2.20 TERMINAL POST INSULATORS

A. Provide a protective insulator for terminal posts having 50 volts or more on them and located on terminal boards in relay houses, relay rooms, relay cases, junction boxes and wayside equipment:

B. Type of insulator:

1. Individual insulated sleeve and nut for each terminal post. (Insulated nut is over and above the double nut requirement.)
2. Fire resistant.
3. Sleeves will be cut to fit around the protrusions of the solderless terminals.

2.21 TERMINALS FOR WIRES AND CABLES

A. Solder terminals: Comply with AREMA C&S Manual 10.4.1, Recommended Instructions for Wire and Cable Installation and Maintenance, and manufacturer's recommendations.

B. Solderless terminals:

1. Comply with AREMA C&S Manual 14.1.1, Recommended Design Criteria and Functional/Operating Guidelines for Solderless Crimp-Type Wire Terminals for Use in Wiring Signal Apparatus, unless otherwise specified.
2. Crimp on type, designed such that flexibility of conductor is not destroyed and possibility of breakage at terminal is reduced to a minimum.
3. Terminals will be insulated ring-type.

4. Barrel insulation will be a stepped nylon material whose diameter increases to accommodate expanded conductor insulation. Conductor insulation will extend into the mouth of the terminal insulation.
5. Barrel will include internal serrations. Palm will be of a thickness not less than 0.05 inches.
6. Submit samples for approval.
7. Acceptable Manufacturer/Products:

    a. Stranded insulated wires 16-12 AWG.: Panduit Heavy-Duty Ring Terminals, Nylon Insulated, P/N PN12-56HDRX.
    b. Stranded Insulated wires 12-10 AWG.: Panduit Heavy-Duty Ring Terminals, Nylon Insulated, P/N PN10-56HDRX.
    c. Stranded insulated wires 16-14 AWG.: Panduit Heavy-Duty Ring Terminals, Nylon Insulated, P/N PN14-56HDR.
    d. Stranded insulated wires 22-18 AWG.: Panduit Heavy-Duty Ring Terminals, Nylon Insulated, P/N PN18-56HDR.
    e. The -56 portion of the part numbers listed above specifies terminals compatible with installation on 5/16 inch studs. Contractor to be responsible for furnishing and installing part numbers that are compatible with the actual terminal stud sizes based on application.
    f. All manufacturer and part number information listed above is exemplar. The Contractor may submit alternate, equals for approval.

C. Compression Tool:

1. Terminals to be designed for attaching to wires with a tool manufactured by terminal manufacturer.
2. Tool to be equipped with ratchet device that will not release until proper indentation is complete.
3. If specialized tool is required to connect terminal to wire, provide the CTA a minimum of two tools for each location containing the specialized connectors/terminals.

PART 3 - EXECUTION

3.01 TYPE REQUIREMENTS

A. Conduit:

1. Under ballast outdoors:

    a. RTRC.

2. Under track:

    a. RTRC encased in reinforced-concrete.

3. 600 VDC positive and negative cables:

    a. RTRC.

4. Installed in trackway:

    a. RTRC.

5. Between Switch-and-lock movements and Terminal Cases:

    a. FNMC (between terminal case and machine).

6. Cable entrance:

    a. RTRC, 4” (minimum).

B. Padlocks and Keys:

1. Provide padlocks/keys and barrel locks according to the following:
2. Dual control switch machines:

    a. Provide barrel locks for cast lids to circuit controller and main crank compartments as well as any other compartment that is capable of being locked.
    b. Provide two padlocks for each switch machine, one for each hand throw pedal stand.

3. Work Ahead control boxes:

    a. Adlake type switch locks.

4. Worker Ahead Signal and Color Light Signal Lamp Compartments:

    a. One barrel lock for each lamp compartment cover.

5. Trip Mechanisms:

    a. One barrel lock for each trip mechanism compartment cover.

6. Wayside Junction Boxes:

    a. One barrel lock for each junction box 3-point door latch.

7. Relay Houses:

   a. Provide one Adlake type switch lock for the main door leading to the LCP/anteroom.
   b. Provide barrel locks for all other doors leading to portions of the relay houses that require access by signal maintenance personnel only such as those in the rear of entrance racks or those that provide access to the signal system equipment.
   c. A sliding gate will be installed in the relay houses which will separate the area occupied by the local control panel from that of the area occupied by the signal/train control devices and systems. The Contractor will provide locking provisions on the gate to accommodate a padlock with a ½" medium shackle padlock for these gates. The CTA will install their own padlocks when the system is commissioned.

8. Relay Cases:

   a. Provide barrel locks for each 3-point door latch.

9. Other signal apparatus containing hinged or removable doors:

   a. Provide barrel locks

C. Terminals for Wire and Cable:

1. Solder Terminals:

   a. Permitted only where recommended by relay manufacturer for vital relay connections.

2. Stranded copper wire:

   a. Provide approved solderless terminal where wires terminate on terminal binding posts.

3. Heavy wire or signal power wire:

   a. Solderless compression connectors.

3.02 LOCATION REQUIREMENTS

A. Surge protection:

1. Provide for line circuits outside tunnel and line circuits that connect a tunnel location to a location outside the tunnel.

3.03 INSTALLATION

A. Install materials, components, and products specified in this section in accordance with details of respective technical sections of these Specifications and in accordance with Contractor's approved installation drawings.

B. Flexible Hose:

1. Clamp hose at both ends with stainless steel clamps. After tightening clamps, cut the excess strap material off ½ inch from the worm drive housing. Chamfer or "dog ear" the corners at 1/8 inch.
2. Clamps are not required for track wire risers.

C. Cable Entrance:

1. Provide RTRC conduit complete with one holding device and one bell end bushing for each conduit.
2. Provide one spare entrance conduit assembly for each enclosure.
3. Sealing cable entrance with approved sealing compound.
4. Cables which are weatherized utilizing gels, grease compounds, or otherwise known to propagate flames to be housed in a metallic conduit to within three inches (3") of the final termination point. EMT or flexible conduits to be submitted for approval. Cables meeting these criteria to not have slack stored within the signal house/room. This includes fiber optic and telephone cables.

D. Environmental Protection:

1. Protect machined finished surfaces, threaded rods, nuts, and other parts that are susceptible to rusting with approved corrosion prevention compound.

3.04 INSTALLATION OF IDENTIFICATION

A. Wire and Cable: Permanently identify both ends of each cable, each cable wire, and single wires that terminate in signal cases, junction boxes, signals, switch mechanisms, and control panels.

1. Ring out and identify each conductor of cable before applying tag.
2. Individual wire tags to conform to the information specified in section 2.08.F of this specification.
3. Cable tags to conform to the information specified in section 2.08.K of this specification.

PART 4 - MEASUREMENT AND PAYMENTMEASUREMENT

A. The work of MISCELLANEOUS COMPONENTS AND PRODUCTS shall not be measured for payment.

4.02 PAYMENT

B. No separate payment shall be made for the work covered in this section. Payment for the Work of MISCELLANEOUS COMPONENTS AND PRODUCTS shall be included in the contract lump sum price as shown in the Schedule of Prices for SIGNAL AND TRAIN CONTROL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

C. Signal and Train Control Work: 344200

END OF SECTION

SECTION 34 42 40
EXTERNAL SIGNAL CABLE

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes:

1. Furnishing and installing single and multi-conductor insulated and jacketed wire and cable required for signal circuits and signal power system wiring external to wayside relay houses/rooms, cases, junction boxes, wayside signal appliances, impedance bonds and buildings.
2. Types of cable includes:

a. Signal and Power Cable / Train Detection and Annunciator Cable.

i. Suited for direct burial in duct banks in ballasted track.

ii. Suited for applications along barrier walls or on the elevated structure. (UV protected)

iii. Suited for duct bank and aerial applications in tunnels and subways. (low smoke/low toxicity/non-halogen)

B. Related sections:

1. 34 42 38 Miscellaneous Components and Products.
2. 43 42 62 Junction Boxes.
3. 34 42 91 Signal System Tests.

1.02 REFERENCES

A. Reference Standards

1. Section incorporates by reference the latest revisions of the following documents (unless otherwise noted), or if standard is adopted by the Authority Having Jurisdiction, the latest revision adopted:
2. American Railway Engineering and Maintenance-of-Way Association (AREMA).
3. AREMA Communications & Signals Manual of Recommended Practices (C&S Manual).
4. ASTM International (ASTM):
5. ASTM B3, Standard Specification for Soft or Annealed Copper Wire.
6. ASTM B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

7. ASTM B33, Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes.
8. ASTM D257, Standard Test Methods for DC Resistance or Conductance of Insulating Materials.
9. ASTM D412, Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension.
10. ASTM D470 - 05 Standard Test Methods for Crosslinked Insulations and Jackets for Wire and Cable.
11. ASTM D471, Standard Test Method for Rubber Property—Effect of Liquids.
12. ASTM D573, Standard Test Method for Rubber—Deterioration in an Air Oven.
13. ASTM D624, Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers.
14. ASTM D1248, Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.
15. ASTM D2240, Standard Test Method for Rubber Property – Durometer Hardness.
16. ASTM D2863, Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index).
17. ASTM E662, Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials.
18. Code of Federal Regulations (CFR):
19. 10 CFR Part 50, Domestic Licensing of Production and Utilization.
20. Institute of Electrical and Electronics Engineers (IEEE):
21. IEEE 383, Standard for Qualifying Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations.
22. Insulated Cable Engineer’s Association, Inc. (ICEA):
23. ICEA S-19-81/NEMA WC3, Rubber-Insulated Wire and Cable.
24. ICEA S-56-434, Polyolefin Insulated Communication Cables for Outdoor Use.
25. ICEA S-68-516, Standard Test Method for Chlorinated Polyethylene Jacket.
26. ICEA S-95-658/NEMA WC70, Nonshielded 0-2kV Cables.
27. Military Standards (MIL):
28. MIL-DTL-24643, Detail Specification: Cables, Electric, Low Smoke Halogen-Free, for Shipboard Use General Specification for.
29. Ministry of Defense, (UK) Naval Engineering Standards (NES):
30. NES 711, Determination of the Smoke Index of the Products of Combustion from Small Specimens of Materials.
31. NES 713, Determination of the Toxicity Index of the Products of Combustion from Small Specimens of Materials.
32. National Fire Protection Association (NFPA):

33. NFPA 70, National Electrical Code

1.03 QUALITY ASSURANCE

A. Qualifications:

1. Cable manufacturers supplying cable for this Contract must be qualified by the Authority prior to the manufacture of cable. Qualifications to be based on the following past performance criteria:

a. Past Performance and Experience:

i. Cable manufacturer to have:

(a) A minimum 15 years reliable experience on circuit signal cables of this type.

(b) At least 5 Class 1 railroads or rapid transit properties.

(c) A minimum 2 million cable feet installed.

ii. Cable manufacturer to demonstrate previous successful experience supplying cable to railway or transit industry for signal control.

b. Provide list of such installations for each proposed manufacturer quality Assurance Program:

i. Cable manufacturer to demonstrate compliance with an ISO 9001 Quality Assurance Program that ensures a thoroughly tested cable with long service life.

ii. Focus will be on formal assurance that cable failure cannot be attributed to actions or lack of actions by manufacturer.

iii. Demonstrate compliance with requirements of this Specification for each specified cable type proposed.

iv. Perform demonstration tests as required by the Authority.

c. Traceability:

i. Each finished wire and cable to be traceable to the test data on file for each step in its manufacturing process.

ii. Cable manufacturer to formulate, prepare, and apply conductor insulating materials and cable outer coverings and to perform conductor insulating, cable assembly, and testing in its own plant(s).

iii. If manufacturer does not normally prepare insulating materials in its own plant(s), it is acceptable for manufacturer to have its

proprietary formulations compounded at another non-owned facility.

iv. Non-owned facilities to be subject to the same Quality Assurance procedures and systems the manufacturer uses in its own facilities and to be subject to audit by the Authority under requirements of 10 CFR Part 50, Appendix B.

v. If an outside facility is used, submit a notarized copy of attached Quality Assurance Program form completed by the outside facility prior to award of contract.

d. Quality Assurance Plan:

i. Plan to include procedures for implementing all requirements of these Specifications.

ii. Plan to cover all stages of manufacture, including the following:

(a) Receipt of incoming materials.

(b) Assembly.

(c) Calibration of test equipment.

(d) Final test.

(e) Shipment.

iii. Plan to provide for written documentation of tests and inspections made under the plan and such documentation to be made available at the cable manufacturer's plant for the Authority's inspection.

iv. Revisions to plan to be submitted to the Authority for approval.

(a) Provide data required for the Authority's evaluation and make arrangements for demonstrations and tests, if required.

2. Annual Audits: Manufacturer must satisfactorily pass the annual audits conducted as called for in 10 CFR Part 50 and AAR-M-1003.

1.04 SUBMITTALS

A. Submit the following for review by the Authority:

1. Before ordering, fabricating, or assembling cable, submit the following product data:

a. Full technical data for each type of cable proposed.
b. Certification that each cable supplied complies with the requirements of these Specifications.
c. Cable lubricant.
d. Weatherproof coating.

2. Past Performance Experience:

a. Provide data as required by this Specification for the Authority's CTA evaluation.

3. Quality Assurance Program:

a. Quality Assurance Program and Provide data as required by this Specification for the Authority's evaluation.

4. Quality Assurance Plan:

a. Provide Quality Assurance Plan and data required by this Specification for the Authority's evaluation.

5. Samples:

a. If requested by the Authority, submit samples of each cable type cable proposed.
b. Samples to be equal to those proposed, and be in 4-foot lengths, complete with specified identification.
c. Requested samples to be delivered prior to cable submittal, and will remain the property of the Authority.

B. Prior to shipment of cable, submit the following for review by the Authority:

1. Certified Factory Test Reports, including the following:

a. Report number.
b. Date and location of test.
c. Description of test and test conditions.

i. Complete cable or wire description.
ii. Lot, batch, or reel identification number.
iii. Quantitative test results.
iv. Summary of test results.

v. Information on components of cable tested including batch numbers and physical and electrical properties.

vi. Complete, signed and notarized standard Wire and Cable Test Report Sheet as part of each cable test report.

2. Test reports for all demonstration tests required by the Authority.

C. Prior to installation, submit the following:

1. Shop Drawings:

a. Proposed temporary aerial cable attachment details.

2. Installation Plans:

a. Detailed plans of each cable raceway installation showing hardware to be used.
b. Methods of attachment.
c. Cable routing through junctions.

3. Field Installation Inspection and Test Procedure.
4. Calculations:

a. Structural.
b. Messenger loading of cable used.
c. Manufacturer's recommended maximum pulling tensions for each cable type.
d. Cable pulling tensions for each individual cable pull.

D. Following installation, submit the following for review by the Authority:

1. Cable pull report showing measured pulling tensions for each cable pull.
2. Field Installation Inspection and Test Reports.

1.05 DELIVERY, STORAGE AND HANDLING

A. Protection:

1. After passing factory tests, effectively seal cable against the entrance of moisture.
2. Protect both ends of each length of cable by wrappings of rubber tape and plastic tape, an effective boot taped or sealed into place, or other suitable means approved by the Authority. Friction tape to not be used, except as an external mechanical protection over an adequate rubber or plastic tape.

3. Cable end protection to be adequate to protect the cable in shipment and prolonged external storage in the weather if not immediately employed, regardless of the position of the reel.

B. Cable to be shipped on reels:

1. Each length of cable to be wound on a separate reel.
2. Cable to be closely and tightly wound, in a uniform manner.
3. Inner end of the cable to be secured and accessible but protected from injury.
4. If the inner end of the cable projects through the flange of the reel, the inner end to be protected by a suitable cover of metal having rounded ends and sides and securely fastened in place to protect the cable end.
5. Secure in place both ends of cable on reel, to prevent their becoming loose in transit or handling of reel.
6. Protect cable from damage in shipment by heavy wrapping or wood lagging. The external protective wrapping on reels to be secured by at least two steel bands to ensure damage free shipment.

C. Reels:

1. Reels to be substantial to withstand handling.
2. The diameter of the reel drum to be at least 14 times the cable diameter to prevent damage to the cable during reeling.
3. The maximum width of reel to not exceed 48 inches unless otherwise specified.
4. The arbor hole to admit a spindle 2-1/2 inches in diameter without binding.
5. The reels to be designated and constructed as non-returnable when drum size and cable weight and volume permit.
6. An arrow to be painted on one head of each reel pointing the opposite direction from the outer end of the cable with the words "Roll This Way" in letters not less than 3/4-inch high and an arrow not less than 6-inches long and 1/2-inch wide.

D. Identification:

1. Each reel to contain a weatherproof tag, firmly attached to the reel, showing the following:

a. Size of conductor;
b. Type of conductor;
c. Number of feet;
d. Gross weight;
e. Type of jacketing;
f. Name of manufacturer;
g. Date of manufacture;
h. Other necessary information.

E. Contractor to be responsible for a change in the shape of the cable occurring in normal shipping that results in an increase in the maximum diameter beyond that specified.

1.06 WARRANTY - CABLE

A. Contractor to certify compliance with the following warranty before selection of the cable manufacturer:

1. Manufacturer warrants that design, material, and workmanship incorporated into cable to be of the highest grade and consistent with established standards for aerial and underground cable for railroad signal, power circuit, train detection and annunciator applications.
2. Manufacturer warrants that each item and component complies with this Specification.

B. Contractor to provide warranty from cable manufacturer that cable provided is free from defects in material and workmanship and agrees to replace cable that is unsuitable for operation or fails in operation during normal and proper use.

1. Warranty for signal and power cable to be for a period of 40 years from date of acceptance of cable, and to apply whether the defect is patent or latent.
2. Warranty for train detection and annunciator cable to be for a period of 3 years from date of acceptance of cable, and to apply whether the defect is patent or latent.

C. The warranty covering any length of cable that to be replaced by the Manufacturer to be replaced for a period of forty years effective as of the day said replacement id effective.

D. These warranties are exclusive and in lieu of all other warranties, written, oral, implied or statutory (except as to title and freedom from lien). In no event to Manufacturer be liable by reason of breach of warranty for special or consequential damages.

PART 2 - PRODUCTS

2.01 GENERAL CABLE REQUIREMENTS

A. Types of cable includes:

1. Direct burial – for underground applications in ductbank or in ballasted track.
2. Aerial cable on elevated track structures or on pole line. (UV protected)

B. Cables to be suitable for use in environment to be encountered on a transit signal system.

C. Insulation to cross or ground: Minimum 1 Mega-ohm.

2.02 CABLE APPLICATION

A. Application of cable includes:

1. Main Cables – Cables (express) that run between relay houses/rooms, cases, junction boxes, and buildings, or those cables containing conductors for more than one system function.
2. Local Distribution Cables – Cables that run between a housing or junction box and an individual unit of equipment.
3. Audio Frequency Train Detection Cables – Single twisted pair (local) and multiple twisted pair (express) cables that are used for the detection of trains, the transmission of cab signals or other signal related circuits.
4. Annunciator / Supervisory Cables- Multiple twisted pair (express) cables that run between relay houses/rooms and communication rooms/houses or stations used to transmit train operations statuses and information such as next train arrival PA triggering, bus holding light control, etc..

B. Cable sizing and use:

1. The Contractor to be responsible for sizing all of the conductors and cable makeup if greater than specified due to application of this design. Increase in conductor size to be approved by the Authority and have no effect on the value of the Project.
2. Multi-conductor main express cable for audio track circuits, annunciators and supervisory.

a. These are main express cables, comprised of twisted pairs, provided along the right-of-way between relay houses/rooms, and terminating in each track circuit junction box.

b. The number of conductors to be determined by the Contractor, and to meet the following:

i. Cables to be one size, with the same number of conductors in each segment between relay houses/rooms. Different sized cable for each segment will not be allowed.

ii. Twenty percent minimum spare conductor pairs to be provided in each segment for each track.

iii. The number of pairs per cable to not be less than twelve.

c. Based on the above three requirements, the Contractor to:

i. Determine the number of working pairs required in each section and for each track between relay houses/rooms.

ii. Determine the maximum of these values.

iii. Multiply the maximum by 1.2 to determine the minimum number of spares to be provided for audio train detection and supervisory express cable for the entire length of the project.

3. Main express cable for line circuits.

a. These are main express cables provided along the right-of-way between relay houses/rooms for line circuits. These cables to be terminated in track circuit junction boxes along the express run at an interval no greater than 1500 feet.

b. The number of conductors to be determined by the Contractor, and to meet the following:

i. Cables to be one size, with the same number of conductors in each segment between relay houses/rooms. Different sized cable for each segment will not be allowed.

ii. Twenty percent minimum spare conductor pairs to be provided in each segment.

iii. The cable size to be a standard signal cable size, 19, 21, 27 or 37 conductor cable. Use of cable with less than 19 conductors will not be allowed.

c. Based on the above three requirements, the Contractor to:

i. Determine the number of working pairs required in each section and for each track between relay houses/rooms.

ii. Determine the maximum of these values.

iii. Multiply the maximum by 1.2 to determine the minimum number of spares and round up to 19, 21, 27 or 37 to determine the number of conductors to be provided for line circuit cable for the entire length of the project.

iv. If more than 37 conductors are required, multiple cables to be provided.

4. Main express cable for traffic line circuits.

a. These are main express cables provided along the right-of-way between relay houses/rooms for line circuits. These cables to be terminated in track circuit junction boxes along the express run at an interval no greater than 1500 feet.

b. The minimum cable provided to be:

i. 12 conductor 9 AWG or larger as required, for two tracks, to prevent voltage drop from inhibiting operation.

c. The Authority's standard traffic circuitry design requires 10 working with 2 spare conductors. If the Contractor's design differs in the number of conductors, the 1.2 multiplier as used for above spare cable requirements to be used.

5. AF track circuit connection cable:

a. Cables provided for installation between track circuit junction box and impedance bond or tuning unit if one is required, to be a single twisted pair No. 14 AWG.

6. AC track circuit connections:

a. Cables provided for installation between relay houses/rooms and the rails to be two separate twisted single 9 AWG conductors.

i. The two conductors to be twisted one turn per foot.

7. AF loop connections:

a. Cables provided for installation between relay houses/rooms and the loop junction boxes to be a single twisted pair 14 AWG.

i. The cable for loops to be a single 9 AWG. Transposed every fifty feet or less (with a minimum of one transition per loop).

8. Color light signal cable:

a. Cables provided for installation between relay houses/rooms and color light signals to be a twelve conductor 14 AWG.

9. Electric train stop cable:

a. Cables provided for installation between relay houses/rooms and electric train stops to be a twelve conductor 14 AWG.

10. Route selector cable:

b. Cables provided for installation between relay houses/rooms and route selectors to be a twelve conductor 14 AWG.

11. Electric switch-and-lock movements:

a. Cables provided for installation between relay houses/rooms and the switch junction boxes to consist of a five conductor 9 (minimum) AWG, and a twelve conductor 14 AWG. A composite cable that includes both may be submitted to the Authority for consideration.

i. The Contractor to perform voltage drop calculations for the 9 AWG cable, and to provide larger conductors if required.

12. Electric Switch Light:

a. Cables provided for installation between relay houses/rooms and electric switch lights to be a two conductor 9 AWG.

13. Electric locks and circuit controllers:

a. Cables provided for installation between relay houses/rooms and junction boxes to be a seven conductor 14 AWG.

14. Worker Ahead signals:

a. Cables provided for installation between relay houses/rooms and Worker Ahead junction boxes or control boxes to be a twelve conductor 14 AWG.
b. The signal lighting cables provided for installation between the Worker Ahead control boxes and the signals to be a three conductor 14 AWG.

15. Snow melter control cases:

a. Cables provided for installation between the relay houses/rooms and snow melter control cases to be a seven conductor 14 AWG.

16. Snow melter power tap:

a. Cables provided for installation between the contact rails and the snow melter control cases to be a one conductor 6 AWG., rated for 1000 volts dc.

17. Snow melter elements:

a. Cables provided for installation between the snow melter control case and the positive end of each heating element to be a one conductor 9 AWG., cable rated at 1000 volts dc.
b. Cable provided for installation from the negative end of the element to the negative running rail or impedance bond neutral to be a 9 AWG cable. Both ends rated at 1000 volts dc.

18. AVI:

a. Cable provided for installation between the AVI RFID readers back to the signal house/room to be a four twisted pair 20 AWG. plus one 22 AWG.conductor, shielded cable.

19. Ground wire:

a. Ground wires case/house/room grounding to be a 6 AWG stranded copper with green EPR insulation.
b. Wayside equipment grounding wire to be single conductor 6 AWG stranded bare copper.
c. Grounding wires for bonding equipment to the structure to be single conductor 6 AWG., stranded bare copper.

20. Source signal power distribution:

a. The cables provided for installation between the Utility source(s) and the relay houses/rooms to provide the 120/240-volt single-phase signal power distribution to be three single conductor, stranded copper cables with conductor size determined by the Contractor, insulated in accordance with ICEA Standard Publication S-19-81.

b. The cables provided for installation between the power inverter and the contact rail/impedance bond to be two single conductor No. 4/0 AWG., insulated cables, stranded copper.

c. The Contractor to perform voltage drop calculations on all above cables, and to provide larger conductor if required.

d. All above cables to be rated for 1000 volts dc.

21. Annunciator / buss holding cables:

a. Cables provided for installation between signal houses/rooms and communication houses and station platform rooms to be 6 pair, No. 18AWG.

C. Local and Express cable plans are shown on Contract Drawings.

2.03 SIGNAL CABLE – DIRECT BURIAL / IN DUCT AND AERIAL ON ELEVATED SATRUCTURES

A. Conductor:

1. Soft or annealed copper, tinned or lead alloy coated, conforming to ASTM B33 or ASTM B189 respectively.
2. Stranded in accordance with ASTM B8; 7- or 19-strand, unless otherwise specified or indicated.
3. Dc Resistance: Conform to ICEA S-95-658/NEMA WC70.

B. Insulation:

1. Material:

a. Ethylene propylene rubber (EPR) compound meeting the following dimensional, electrical, and physical properties:

i. At a minimum, physical and electrical performance requirements of AREMA C&S Manual 10.3.19, Recommended Design Criteria for Ethylene Propylene Rubber Insulation for Wire and Cable.

ii. Requirements of Tables 8 and 9, where these requirements exceed requirements of AREMA C&S Manual, Part 10.3.19.

2. Apply conductor insulation directly to surface of conductor such that it adheres tightly but is free stripping so as to leave conductor clean.
3. Installation Temperature Rating:
    a. Minus 40 degrees C (minus 40 degrees F) with no cracking.
4. Rating:
    a. 1000 V, continuous operation at 75 degrees C in wet or dry locations.

C. Individual Conductors of Multi-Conductor Signal Cable:

1. Insulation thickness:
    a. Direct burial or in ducts:
        i. In accordance with Table 3, AREMA Class A.
    b. Above grade or aerial:
        i. In accordance with Table 3, AREMA Class B.
2. Identification:
    a. Uniquely identify each individual conductor with numbers:
        i. Print directly on conductor insulation.
        ii. Write number and spell out numbers, starting with "1-one" and continuing in sequence without repetition until all conductors are identified (i.e.: 1-one, 2-two, 3-three, etc.).
    b. Color:
        i. Dark brown or black insulated wire: White ink.
        ii. Orange insulated wire: Black ink.
        iii. Light Red Insulated wire: Black Ink
    c. Configuration:
        i. Print in two parallel lines 180 degrees apart, with one line reversed in direction relative to the other.
    d. Spacing:
        i. Repeat a minimum of every 6 inches for entire length of cable.

D. Multi-Conductor Cable Assembly – Direct Burial / In Duct

1. Cabling:

a. Using individual conductors, as specified above, cable helically with adjacent layers wound in opposite directions.

2. Fillers:

a. Flame and moisture resistant; use where necessary with cabled conductors to assemble cable into a tight cylindrical core.

3. Cushion layer:

a. Moisture resistant, shock-absorbing, cushioning tape or elastomeric material; cover cable core.

i. Cushioning tape:

(a) Compound filled, compatible with conductor insulation. Apply helically, 10-mil minimum, with minimum 12.5 percent overlap.

ii. Elastomeric material thickness:

(a) In accordance with Table 4.

4. Outer Jacket:

a. Black, extruded, low density, high molecular weight, polyethylene.
b. Meet ASTM D 1248, material Type I, Class C, Grade E5.
c. Thickness:

i. Per Table 5, at the end of this Section.

d. Physical characteristics:

i. Per Table 10, at the end of this Section.

E. Multi-Conductor Cable Assembly – Aerial on Elevated Structures

1. Cabling:

a. Using individual conductors, as specified above, cable helically with adjacent layers wound in opposite directions.
b. Flame and moisture resistant; use where necessary with cabled conductors to assemble cable into a tight cylindrical core.

2. Tape Covering:

a. Moisture resistant; cover overall.

3. Outer Jacket:

a. Chlorinated polyethylene (CPE), conforming at a minimum to requirements of AREMA C&S Manual Part 10.3.20, Recommended Design Criteria for Chlorinated Polyethylene Jacketing for Wire and Cable.

b. Thickness:

i. Per Table 6, at the end of this Section.

c. Physical characteristics:

i. Per Table 10, at the end of this Section, where these requirements exceed requirements of AREMA C&S Manual, Part 10.3.20.

F. Single Conductor Cable – Direct Burial / In Duct

1. Insulation Thickness:

a. Per Table 7.

2. Outer Jacket:

a. Same requirements as for multi-conductor cable assembly for underground direct burial and duct cables.

G. Identification – Multi-conductor Cable and Single Conductor Cable:

1. Permanently identify each length of cable:

a. Multi-conductor cable:

i. Moisture resistant marker tape under jacket, parallel to longitudinal axis of cable, with bold, easily read, permanent characters; or

ii. Information indelibly embossed or printed on jacket.

b. Single-conductor cable:

i. Information indelibly embossed or printed on jacket.

c. Required information:

i. Name of manufacturer.

ii. Year manufactured.

iii. Size and type of cable (i.e.: 27c#14, 12c#14, etc.)

iv. Relative footage marker number: Increment based on interval of spacing of identification marks; difference between two footage markers to accurately calculate length of cable segment.

d. Spacing: Minimum every 3 feet.

2.04 MULTI-TWISTED PAIR SIGNAL AUDIO FRECUENCY TRAIN DETECTION

A. General Requirements:

1. Train Detection, annunciator and supervisory control cables intended for installation in ducts, open air, or buried in earth to be rated to withstand a maximum rated circuit voltage of 1000 VDC and to be rated for 75°C continuous.
2. All pairs to be guaranteed for end-to-end continuity and to be free of such manufacturing defects as short circuits, crosses, or opens.

B. Material Requirements:

1. Where characteristics are not specifically defined by the following, the ICEA S-56-434 and ICEA S-95-658/NEMA WC70 to apply and govern.
2. Conductors:

a. Soft, annealed copper, #14AWG
b. Stranded in accordance with ASTM B8; 7-strand.
c. Meet ASTM B3 requirements for elongation and resistivity before insulating

C. Conductor Insulation:

1. Polyethylene-PVC.
2. Each conductor will have a duplex type of covering with the first layer over the copper being polyethylene and the exterior layer or jacket being PVC.
3. The overall thickness of the combination to be not less than 30 mils.
4. The nominal polyethylene thickness to not be less than 20 mils
5. And the PVC covering to be nominally not less than 10 mils.
6. The PE insulation to be in accordance with AREMA Signal Manual Part 10.3.16.E, Type III for polyethylene insulated conductors.
7. The polyethylene to comply with or exceed the applicable requirements of the latest revision of ASTM D1351

a. The PVC insulation to be in accordance with AREMA Signal Manual Part 10.2.23. It to be colored and to comply with Paragraph 3.7 and/or 3.8 of IPCEA-NEMA Standards Publication Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (ICEA Pub. No. S-61-402; NEMA Pub. No. WC5).

8. Pairs-two conductors are assembled with a random length twist to form a twisted pair. Pairs to be formed from consecutively numbered odd then even conductors.
9. Identification of cable pairs/conductors:

   a. One conductor to be black and the other to be white for each pair.
   b. Black conductors to use white ink for numbering, and white conductors to use black ink for numbering.
   c. Black conductors to have odd numbers, identified as “1-ONE”, “3-THREE”, “5-FIVE”, etc. The matching pair for each black conductor to be a white conductor stamped with the next even number: “2-TWO”, “4-FOUR”, “6-SIX”, etc.

10. Alternate identification of conductors to be as follows, subject to approval:

    a. One conductor to be a color and the other to be white with a color tracer stripe that matches the color. There to be no color duplication amongst the pairs in the cable. The colors to be in sequence and comply with ICEA Method 5, which show colors and tracer colors.

11. Cylindrical core: Conductors to be twisted into pairs and arranged in layers to in accordance with ICEA S-56-434, Section II-9.
12. The core to be completely covered with one or more layers of moisture-resistant material to provide separation between the core and inner jacket.
13. Outer Jacket:

a. Jacket (sheath) to be in accordance with AREMA Signal Manual Part 10.3.16.G, Type II for polyethylene jackets.
b. Purpose: Provide protection against mechanical damage and entrance of moisture, earth acids, and alkalis into cable.
c. To not adhere to insulated conductors of multiple-conductor cables and to conform to Table 2.
d. Applied by continuous tube method, without joints.
e. Average thickness of sheath compound for multi-conductor cables to be not less than values specified in Table 1.
f. Average mutual capacitance of all pairs in a reel: Maximum 0 .083 mfd per mile in accordance with ICEA S-56-434 Section II-20.

14. Output-to-output, far end cross-talk loss: Comply with ICEA S-56-434 Section II-20.
15. Provide name of manufacturer and year manufactured in bold, easily read, permanent characters. This information may be embossed on the jacket or imprinted on a tape inserted within the cable.

2.05 BUS HOLDING AND TRAIN ARRIVAL ANNUCIATOR CABLE

A. General Requirements:

1. Cable to be 18AWG, 6 –pair, 7-strand bare copper with polyvinylchloride and nylon insulation, unshielded with an overall PVC jacket, 600V control tray cable, approved for use in Sunlight-resistant Direct-burial and Oil-resistant I 90°C applications.
2. All pairs to be guaranteed for end-to-end continuity and to be free of such manufacturing defects as short circuits, crosses, or opens.

B. Material Requirements:

1. Conductor:

a. 18AWG, 7 Strands, Class B.
b. Annealed bare copper.
c. Pair count to be 6 pairs.

2. Insulation:

a. Material to be Polyvinylchloride & Nylon.
b. Wall thickness to be 0.015”PVC & 0.005” Nylon.
c. Color code to be black and white numbered pairs.

3. Assembly:

a. Pair/cable lay length to be Per UL Standard 1277.

4. Jacket:

a. Material to be Polyvinylchloride.
b. Wall thickness to be 0.060” minimum.
c. Diameter to be 0.545” minimum.
d. Color to be black.
e. Ripcord to be provided.
f. Cold bending rating to be -40°C.

5. Markings:

a. Cable to be permanently identified via surface inkjet print.
b. Manufacturer’s Name, Cable Identification part number, Lot Number, Standard Manufacturer’s cable properties identifications for type and all ratings.
c. Provide footage markers.

6. Standards:

a. Cable to be suitable for use in Class I Division II hazardous locations.
b. UL Listing to be Type TC-ER per UL Standard 1277 for tray cables.
c. UL Approved for Direct Burial (DIR BUR), Sunlight (SUN) and Oil (OIL) resistant applications.
d. Flame Test for individual conductors pass UL VW-1, rated THHN/THWN/VW-1.
e. Meet UL 1581 and 1202 (FT-4) 70,000 BTU/HR and ICEA T-29-520 210,000 BTU/HR requirements
f. Meet ICEA S-73-532, where applicable.
g. Refer to NEC (NFPA 70) for Supplemental Installation Guidelines.

7. All materials used in manufacture of this cable are RoHS compliant.

2.06 MESSENGER CABLE SUPPORT

A. Messenger Materials:

1. High-tensile strength, seven strand, copper clad, 30 percent HS-7W messenger.
2. Size:
    a. Determine diameter of messenger required for proposed cables.
    b. Minimum diameter: 5/16 inch.
3. Messenger brackets and hardware to be galvanized.
4. Suspension clamps to be galvanized steel, 3-bolt type.
5. Messenger hangers to be galvanized steel.
6. Pole line hardware and messenger brackets for concrete pole line to be galvanized steel.
7. Acceptable Manufacturers/Products.
    a. Suspension clamps: Maclean Power Systems J-931, or approved equal.
    b. Messenger hangers: Maclean Senior Industries J1070, or approved equal.
    c. Cable straps for cables: Thomas & Betts TY54407X, or approved equal.
    d. J-hooks for cables with integrated messengers: Maclean Power Systems J-2235, or approved equal.
    e. Automatic guy splices: Hubbel Power Systems GLS500x or GLS504x-series (EHS) or approved equal.

B. Messenger Design:

1. Provide structural calculations for support system components and messenger loading.
2. Base loadings upon a heavy loading district per the National Electrical Safety Code.

2.07 MISCELLANEOUS PRODUCTS

A. Wire and Cable Tags:

1. See Section 34 42 38, Miscellaneous Components and Products.

B. Sealing Compound:

1. See Section 34 42 38, Miscellaneous Components and Products.

C. Cable Lubricant:

1. Glycerized liquid or other approved lubricant, non-injurious to cable insulation, as recommended by manufacturer.

D. Weatherproof Coating:

1. 3M™ Scotchkote™ Electrical Coating, or approved equal.

2.08 SOURCE AND QUALITY CONTROL

A. Testing Notification:

1. Notify the Authority in writing a minimum of thirty days in advance of final testing, so that the Authority may witness tests if it so elects.

B. Contractor Inspection:

1. Monitor wire and cable manufacturer to ensure that approved Quality Assurance Program is closely followed by cable manufacturer and that wire and cable is manufactured in accordance with this Specification and approved submittals.

C. Authority Inspection and Testing:

1. The Authority or its authorized representative to have the right to make such inspection and tests as necessary to determine if cable meets requirements of this Specification.
2. The Authority to have the right to reject cable that it deems to be defective or not meet the Specifications.

D. Design Tests:

1. Test insulated conductors to demonstrate that they meet the following requirements:

   a. At a minimum, signal cable for use above ground or underground, and aerial conductors to meet physical and electrical performance requirements of AREMA C&S Manual 10.3.19, Recommended Design Criteria for Ethylene Propylene Rubber Insulation for Wire and Cable.
   b. Conductors to meet requirements of Tables 8 and 9 where these requirements exceed requirements of AREMA C&S Manual, Part 10.3.19.
   c. Jacket material to meet the requirements of Table 9 or Table 10, depending on jacket type.
   d. List actual values of the tests performed.

E. Production Tests:

1. Physical Tests:

a. Select samples at random at place of production.
b. Take each test sample from accessible end of different reels.
c. Identify each reel selected and corresponding sample.
d. Number and lengths of samples to be as specified under individual tests.
e. Perform all applicable tests for cable materials and cable construction specified.

2. Manufacturer to provide, at the point of production, apparatus and labor for making any or all of the following tests under supervision of the Authority's inspector:

a. Conductor size and physical characteristics.
b. Insulation HV and IR tests.
c. Physical dimension tests.
d. Special tests on materials in coverings.
e. Final HV, IR, and conductor resistance tests on shipping reels.

3. Single Conductors:

a. Dry "Spark" Test: Pass single insulated conductors through high voltage test electrodes energized with a minimum of 10 kV, 60 cycle ac to insure detection of damage to conductor insulation.
b. Ac Test (Wet Tank):

i. Before assembly into cable, randomly wind each insulated conductor on reels, submerge in water for minimum 24 hours.

ii. Subject to 5 minutes of 60 HZ ac test voltage, per Table 3 at the end of this Section.

4. Insulation Resistance Tests:

a. Perform test immediately after ac test, while conductor is still submerged.
b. Perform on each length of conductor.
c. The insulation on resistance constant, "K", in the following formula, when corrected to 15.6 degrees C (60 degrees F), to not be less than 35,000 megohms per 1000 feet.

i. R = K Log10 (D/d)

ii. R = Insulation resistance in megohms per 1000 feet at 15.6 degrees C (60 degrees F)

iii. K = 35,000 megohms constant, 1000-foot unit

iv. D = Diameter over conductor insulation.

v. d = Diameter under conductor insulation.

5. Dc Test:

a. Perform test immediately after insulation resistance test, while conductor is still submerged.

b. Subject each coil or reel length of insulated conductor to dc test voltage, as shown in Table 3 at the end of this Section, for 10 minutes.

c. Conductor to withstand test.

6. Cable: During process of cabling, and before applying overall coverings, perform the following test:

a. Dry "spark" test: Pass cable through high voltage test electrodes energized with a minimum of 10 kV, 60 cycle ac to insure detection of damage to conductor insulation.

7. Finished Cable Tests:

a. Signal Cable for use above ground or underground, and aerial conductors:

i. Conductor resistance:

(a) Verify cable conforms to ICEA S-95-658/NEMA WC70.

i. Insulation resistance test:

(a) Perform using the 60 Hz ac test voltage or dc test voltage from Table 3 at the end of this Section.

(b) Test from conductors to ground obtained by water immersion of nonmetallic shielded cables and between each conductor and every other conductor with which it comes into contact in the cable.

8. Communication and supervisory control cables:

a. Test at factory.

i. Cable to meet or exceed requirements of ICEA S-56-434, Section II-20.

ii. Complete tests specified in Table 2.

iii. Each completed cable to pass the IEEE 383 70,000 BTU/hour Vertical Tray Flammability Test.

9. Test Reports:

   a. Submit certified electrical and physical test reports for finished multiple conductor cables no later than time of shipment.
   b. Each test document to include the following:

      i. Test results.
      ii. Date tests were performed.
      iii. Signature of Manufacturer's authorized representative.

PART 3 - EXECUTION

3.01 GENERAL CABLE INSTALLATION REQUIREMENTS

A. Notice to the Authority: Give 48 hours' notice before installing cables.

B. Install wire and cable in accordance with AREMA C&S Manual 10.4.1, Recommended Instructions for Wire and Cable Installation and Maintenance, except as specified otherwise in this Section.

C. Cable runs to be continuous without splices between cable terminating locations. No splices to be made in vital, non-vital or train detection signal cables

D. Provide end bell to prevent damage to cable at transitions from conduit to messenger or tray as specified in these Specifications.

E. Separation:

1. Cable carrying 480 or more volts to not be installed in the same trench or conduit as signal or communication cable, except as otherwise specified.

F. Cable Installed in Conduit:

1. Cable fill, in conduit, to not exceed 40 percent, unless otherwise allowed by the Authority.
2. Install all cables to be placed in one duct simultaneously.
3. Lubrication: Use approved cable lubricant when pulling cables into conduit, pipe, or duct bank.
4. Pull cables into conduit or pipe without crossing one with another.
5. Conductors to not be pulled tight or kinked in conduit fittings or boxes.
6. Use extreme care in installing cables to avoid twisting, kinking, or injuring cable or its sheath.
7. Provide pulling cords in each conduit.
8. Do not use spare conduit without approval from the Authority.

G. Cable Radius:

1. Minimum 10 times diameter of cable, during installation and as finally installed.

H. Cable Slack:

1. Provide sufficient slack in conductors at terminating posts for three re-terminations of conductor due to broken eyelets without re-servicing or re-potheading cable.
2. Where cable is subject to equipment vibration, provide slack for flexibility.

I. Special Protection:

1. Provide appropriate special protection for cable in areas where unavoidably exposed to hazardous conditions such as vibration or sharp corners on equipment.
2. Cable to be laid on tarps so as not to come into contact with any surfaces between reel and duct or hanger when pulling and hanging cables.
3. Replace, at no additional cost to the Authority, provided cable that is damaged before acceptance as a result of Contractor's failure to provide protection.

J. Termination:

1. Multiple conductor cables:

    a. Carefully remove outer sheath of cable to point of cable entrance.
    b. Apply two layers of plastic electrical tape at end of cable sheath or covering.

2. Terminate cables in conductor order.
3. Terminate each spare conductor in each cable.

K. Sealing Openings:

1. After cable is in place, seal openings in equipment enclosures and junction boxes with either a compression type fitting or pliable sealing compound.
2. Seal area around cable where cable emerges from the end of a conduit, pipe or duct bank using sealing compound.
3. Seal or plug spare and empty, abandoned conduits in an approved manner.

L. Identification:

1. Cables:

a. Provide a cable tag for each cable.
b. Mark/stencil tags with cable identifier, destination and number of conductors in cable.

M. Conductors:

1. Identify individual conductors at each cable termination with wire tags.
2. Identify each spare conductor in each cable.

N. Cable Entry and Routing:

1. Strip back all cable outer jackets to within 3” of the entrance to the junction box, house or case.
2. Cables to enter the enclosure through the conduit or opening closest to the terminals to minimize crossing other cables or interfering with access to other terminals.
3. Bring the cable wire loom up the top of the enclosure, support from the top with a cable grip.
4. Tree cables down to the appropriate terminal post in a neat and professional manner.

3.02 DIRECTIONAL BORING

A. Start and end pits for guided borings to be hand dug, unless otherwise approved by the Authority.

B. Boring depth to be a minimum of 48 inches to clear existing underground signal cables.

C. All waste materials created during the boring operations and any subsequent reaming operations to be removed from the site by the Contractor.

D. The Contractor to carry out all excavations for entry, exit, recovery pits, slurry sump pits, or any other excavations associated with the directional boring process. Sump pits to be required to contain drilling fluids if vacuum devices are not utilized throughout the drilling process.

E. Within 48 hours of completing installation of the boring materials, the worksite to be cleaned of all excess slurry and spoils.

F. Any removal of any materials installed in a failed bore path to be at no additional costs to the Authority. The Contractor to promptly fill all voids by injecting all taken out of service products that have any annular space with excavatable flowable fill.

G. The approved method of locating and tracking the drill head during the pilot bore to be used. As a minimum, the locating and tracking system to provide clock and pitch

information, depth, transmitter temperature, battery status, “x, y” information, and azimuth information where direct overhead readings are not possible.

H. The Contractor to take and record alignment readings or plot points such that elevations on top of and offset dimensions from the center of the bore to a permanent fixed feature are provided. The permanent feature to be approved by the Authority prior to commencement of boring operations.

1. The Contractor to provide elevations and dimensions at all bore alignment corrections, and at a minimum of every 100 foot segments. A minimum of three elevations and plot points to be provided for each cable run to determine the installed horizontal and vertical alignment.
2. Final readings to be used by the Contractor in his preparation of as-built drawings to show the vertical and horizontal alignments of all conduits installed by the directional boring process. The as-built drawings to also contain all “failed path” and “obstruction encountered” boring locations.

I. The Contractor to minimize the potential damage from soil displacement and settlement by limiting the ratio of the bore hole to the installed conduit diameter. The size of the back reamer bit or pilot bit, if no back reaming is required, to be limited to the conduit diameter as follows:

Nominal Inside Conduit Diameter	Bit Diameter
2 inches	4 inches
3 inches	6 inches
4 inches	8 inches
6 inches	10 inches

J. Drilling fluid for lubrication and soil stabilization to be a mixture of bentonite clay or other approved stabilizing agent and potable water. Use of other chemical agents will require approval of the Authority, and will require certification by the Contractor that the materials used are environmentally safe and not harmful to the facilities. The Contractor to ensure that all drilling fluids are disposed or recycled in a manner acceptable to the appropriate local, state, and federal regulatory agencies.

K. The Contractor to match the boring equipment to be used with the size of conduit to be installed. The Contractor to ensure that the drill rod meets the bend radius required for the installation.

L. The Contractor to ensure adequate removal of soil cuttings and stability of the bore hole by monitoring the drilling fluids such as the pumping rate, pressures, viscosity and

density during the pilot bore, back reaming, and conduit installation. Location of relief holes to relieve excess pressure down hole to be approved by the Authority.

M. Pull back rates to be monitored to minimize heaving. Recommended pull back rates for the size conduit installed to not be exceeded. The Contractor to also contain excess drilling fluids at the entry and exit points until they can be removed from the site. The Contractor to ensure that the entry and exit pits are of sufficient size to contain the expected return of the drilling fluids and soil cuttings.

3.03 OUTDOOR LOCATIONS UNDERGROUND BURIED INSTALLATION:

A. Cables to be installed in concrete encased RTRC conduit along the right of way. Cables to not be installed in metallic conduit of any type.

B. Local cable within ballasted areas to be buried to a uniform minimum depth of 36 inches below finished grade.

C. Restoration of backfill and ballast to be in accordance with the construction methods outlined in the Backfill Section of these Specifications.

D. Where cable leaves the ground at other than buildings or in foundations, it to be protected by a bootleg or other covering extending above the ground line. Top of such protective coverings to be filled with a sealing compound.

E. Where buried cables enter a concrete foundation, junction box, or cases, a five foot slack coil in each cable to be left in a trench below the foundation or pedestal. Cable marker tape to be installed over the slack coil. Slack coils to not be used for cables carrying solid state track circuit frequencies.

F. The potheading of buried cables to be applied whenever cable is terminated in signal equipment and such termination is within 2 feet of the grade level. This chlorinated polyethylene end seal pothead to be installed in accordance with the manufacturer's instructions.

3.04 INSTALLATION OF CABLE IN DUCT BANK

A. Duct bank Preparation:

1. Before installing cable, pump water out of manholes, handholes, and pull chambers.
2. Maintain manholes, handholes, and pull chambers in a dry condition while the cables are being pulled.

B. Conduit Preparation:

1. Blow or swab dry conduit to be used.
2. Rod and mandrel each conduit.
3. Provide pulling cords in each conduit.

C. Cable Pulling:

1. Provide an approved wire cable grip extending not less than 18 inches back from the end of the cable.
2. Lubricate cables with approved lubricant.
3. Place cables in duct bank according to the Contract Drawings. Where more cables are used than the typical, place cables in lowest available duct.
4. Provide cable slack in handholes and manholes in lengths of one turn around the inside perimeter of the handhole from entrance of the cable to exit.

D. Cable Puller:

1. Set clutch to slip at 50 percent of cable weight per 1000 feet.
2. Equip with calibrated dynamometer that indicates pulling force in pounds.
3. Contractor to verify pulling tensions do not exceed manufacturers recommended pulling tension for cable. Contractor to provide intermediate pulling access points.
4. Glycerized liquid lubricant or other approved lubricant to be applied to the cable as approved by the Authority when installing cables in ducts.

E. After Cable Pull:

1. Seal ends of cable immediately after pulling until time for terminating.
2. Fill conduits, all entering manholes or housings, with sealing compound.
3. Properly constrain and fasten cables in manholes to walls of manhole in accordance with Contractor's approved installation drawings.

3.05 NON BURIED INSTALLATION:

A. Installation in Trays or Troughs:

1. Cable installed in trays or troughs to be laid therein and not pulled in place.
2. Where the location of the tray does not allow laying of the cables, suitable rollers or other pulling devices designed for cable trays may be allowed with the approval of the Authority at each location.
3. Cables installed in trays and troughs to have a minimum amount of crossover and to not be pulled tightly around bends.
4. Cables installed in troughs integrated into a concrete deck to be suspended from a messenger wire attached to the wall of the trough at 6'-0" intervals.

B. Installation in Conduit or Pipe:

1. Cables to not cross one another when they are pulled into a conduit or pipe and care to be taken not to have the conductors pulled tight or kinked in conduit fittings or boxes.
2. Furnish and install end-bells on all conduits where cables transition from the conduit to messenger.
3. Support and guide all cables entering conduits. Multiple cables occupying a conduit to be simultaneously pulled.

C. Minimize the use of any lubricating medium for pulling cable through any conduits, and clean up any excess prior to enclosing conduit runs. Lubricant to be suitable for the application and non-injurious to the cable jacket.

3.06 INSTALLATION OF AERIAL CABLE

A. Installation of Messenger Brackets:

1. Existing messenger and cable brackets:

   a. Aerial cable brackets to not be reused.

2. Design, furnish, and install brackets and dead-ends for installation of aerial cables.
3. Provide messenger brackets to support messengers along stringers, from each bent on elevated structure and along walls.
4. Provide additional brackets where needed to redirect messenger to clear platform supports, abutments, and other obstructions along structure or walls.
5. Bracket design to allow minimum clearance of 2 inches from cables to structure or wall at all points along messenger.
6. Spacing:

   a. Fastened to walls:

      i. Tangent track: Minimum every 25 feet.

      ii. Curved runs: Minimum every 12-1/2 feet.

   b. Fastened to elevated structure:

      i. Tangent runs: Minimum every 50 feet or every bent.

      ii. Curved runs: Minimum every 25 feet.

7. Attachment:

a. Walls: Attach with epoxy-type anchors.
b. Structure:

i. Securely attach with bolted connections.

ii. Brackets to not be welded to structure.

iii. Bolt holes to be drilled, and not burned or punched through. Treat bolts with Lock-Tite or approved equal after final installation to prevent loosening from vibration.

B. Installation of Precast Concrete or Fabricated Metal Poles.

1. Install poles at maximum 50’ intervals
2. Install poles at each side of a viaduct
3. Provide guy wires as required to prevent undue stress on the pole.

C. Installation of Messenger:

1. Install loosely in messenger clamps until dead-ended at both ends.
2. After dead-ending tighten all clamps to provide uniform tension in each span.
3. Where sagging tension is applied from the ground by means of a coffing hoist or block and tackle hoist, locate pulling point minimum 75 feet beyond last pulley and in direction of the line.
4. Continuously check tensions during installation of messenger by means of one or more dynamometers.
5. Final tension to not exceed 25 percent of its rated breaking strength at 60 degrees F after initial stretch and cable installation.

D. Installation of Cables on Messenger:

1. Maximum cable bundle supported by a single messenger: 5 inches diameter.
2. Where multiple cables are installed on one messenger, take care to prevent twisting or spiraling of cables. Cables to be dressed in a neat, parallel fashion.
3. When installing cables on messenger, take the following steps:

a. First tie cables to messenger with temporary marline or rope ties close enough together to hold cable without undue sagging or slack.
b. Then permanently tie cables to messenger with cable straps placed on 15-inch centers (maximum).

4. Furnish and install supplemental wire ties consisting of individual strands of 9 AWG wire at all messenger brackets, mid-spans between messenger brackets, at transitions to other messengers or cross-runs, at transitions to or from conduits and at transitions to or from junction boxes. Furnish and install sufficient turns

to neatly bind cables and messenger and to fully support the cables in the event of a complete failure of cable straps.

5. At points where cables leave suspension strand messenger to enter housings or conduit, securely fasten and anchor cables to messenger with sufficient wrappings of nylon filament rope to prevent cables from slipping or sagging.
6. Secure cable bundles and runs at transition points when cable runs or portions of cable runs change direction or branch off.
7. All cable straps and lashings to secure the entire bundle to the messenger or hanger.

    a. When installing additional cables to a cable/messenger run:

        iv. Where cables are added to existing bundles, remove existing straps.

        v. Furnish and install new straps and re-dress the entire bundle.

        vi. Partial securing of additional cables to existing bundles without re-securing and redressing the entire bundle is prohibited.

8. Furnish and install new cable straps and ties for both new messenger runs as well as for securing cables to existing bundles or messenger runs.
9. Secure cables routed to relay housings or rooms, junction boxes, relay cases or making vertical runs with cable clamps properly sized that firmly support the cable. The use of one clamp to secure multiple cables to not be permitted except as approved by the Authority. The use of tie-wraps as permanent support or securing of cables is not permitted.

a. Where messenger is exposed, apply weatherproof coating.

10. Cables and cable bundles to be installed such that no contact will be made between the bundle, messenger or cable and any other fixed or hanging object other than hangers, clamps and fittings intended to secure those specific cables and runs.

a. A minimum of two inches clearance to be provided between cable bundles/messenger and any other object, structure, wall or equipment, taking into account wind loads, other objects or equipment moving, variations in cable sag due to temperature and tension changes.
b. Where this clearance cannot be maintained by any other method, bracket or hanger, the installation to be modified to secure and protect the cables from damage, subject to approval by the Authority.

11. The Contractor to provide appropriate special protection for cables in areas where the cables are unavoidably exposed to hazardous conditions such as vibration or sharp corners on equipment. The Contractor to be responsible for replacing, at no additional cost to the Authority, any cable he has installed which is subsequently damaged prior to acceptance as a result of his failure to provide such special protection.

3.07 TESTS

A. Inspection:

1. After installing, inspect each cable installation in accordance with requirements of Contractor's approved Field Installation Inspection and Test Procedure.
2. Correct noted deficiencies to the satisfaction of the Authority.

B. Test cable in accordance with the Signal System Tests Section of these Specifications.

3.08 EXTERNAL CABLE TABLES

TABLE 1

SUPERVISORY CONTROL CABLE

INNER AND OUTER JACKET THICKNESS

DIAMETER OF CABLE CORE IN INCHES	THICKNESS OF SHEATH IN 64TH OF AN INCH MULTIPLE CONDUCTOR
0 to 0.425	5
0.426 to 0.700	6
0.701 to 1.050	7
0.051 to 1.500	8
1.501 to 2.000	10
2.001 to 3.000	12
3.000 and Larger	14

NOTE: Minimum thickness of sheath compound at each point to not be less than 90 percent of specified thickness.

TABLE 2

PROPERTIES OF POLYETHELYNE SHEATH FOR TRAIN DETECTION CABLE INSULATION

	PROPERTY	TEST METHOD	VALUE
Original	Tensile Strength PSI	ASTM D412	1400 Min.
	Elongation %	ASTM D412	350 Min.

Air Oven Aged	48 hours @ 100C Tensile Str % Original Elongation % Original	ASTM D573 ASTM D573	80 Min. 80 Min.
Low Temp. Flex.	Pass °C	ICEA S-19-81	-55C
Air Oven Aged	168 hours @ 100C Tensile Str % Original Elongation % Original	ASTM D573 ASTM D573	75 Min. 75 Min.
Water Absorption	168 hours @ 70C mg/in^2	ASTM D470	5.0 Max.
Environmental Stress Aging	100% Igepal CO-630 @50C for 48 hours, Failures		None

TABLE 3

INSULATION THICKNESS, CONDUCTORS IN MULTI-CONDUCTOR CABLES

			Test Voltages	
AREMA Class	Conductor Size, AWG	Conductor Insulation	Ac-60 Hz 5 Minutes	Dc 10 Minutes
A	16 to 8	79 mils	10,000	30,000
	6 to 2	94 mils	11,000	33,000
B	16 to 8	62 mils	8,000	25,000
	6 to 2	78 mils	10,000	30,000

NOTE: The insulation thickness specified in Table 3, at the thinnest part of any cross section of insulated wire, to not be less than 90% of that specified. The average thickness to be at least the value shown.

TABLE 4

CUSHION LAYER - ELASTOMERIC MATERIAL THICKNESS

UNDERGROUND DIRECT BURIAL OR DUCT CABLES

Calculated Core Diameter – Inches	Average Cushion Layer Thickness
0-1.500	47 mils
1.501 – Layer	62 mils

TABLE 5

OUTER JACKET THICKNESS

AERIAL (ABOVE GROUND) CABLE

Calculated Core Diameter - Inches	Average Jacket Thickness
Up to 0.425	65 mils
0.4326 to 0.700	80 mils
0.701 to 1.050	95 mils
1.051 to 1.500	100 mils
1.501 to 2.000	140 mils

TABLE 6

EXTERNAL SIGNAL CABLE
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OUTER JACKET THICKNESS

AERIAL (ABOVE GROUND) CABLE

Calculated Core Diameter - Inches	Average Jacket Thickness
Up to 0.425	65 mils
0.4326 to 0.700	80 mils
0.701 to 1.050	95 mils
1.051 to 1.500	100 mils
1.501 to 2.000	125 mils

TABLE 7

INSULATION & OUTER JACKET THICKNESS, TANK TEST

SINGLE-CONDUCTOR UNDERGROUND CABLE

Conductor Size AWG	Insulation Thickness	Polyethelene Jacket Thickness	Tank Test kV Ac 5 Minutes
6	94 mils	62 mils	7.5
8	78 mils	62 mils	6.0
9	78 mils	62 mils	6.0

TABLE 8

INSULATION PHYSICAL CHARACTERISTICS

SIGNAL CABLE

EXTERNAL SIGNAL CABLE
34 42 40 – 39

1. Physical Properties		
Original Requirements:		
Tensile strength	Minimum psi	1000
Tensile stress at 200 percent elongation	Minimum psi	60
Elongation at rupture	Minimum percent	300
Aging Requirements:		
After 168 hour Oxygen Pressure at 80 degrees C (176 degrees F) 300 psi		
Tensile strength	Minimum percent of original	90
Elongation at rupture	Minimum percent of original	85
After 20 hour Air Pressure Heat at 127 degrees C (260 degrees F) 80 psi		
Tensile strength	Minimum percent of original	90
Elongation at rupture	Minimum percent of original	85
After 168 hour Air Oven Aging at 121 degrees C (249.8 degrees F)		
Tensile strength	Minimum percent of original	90
Elongation at rupture	Minimum percent of original	85
2. Mechanical water absorption:		
7 days, 70 degrees C (158 degrees F)	Maximum mg/square inch	8
3. Ozone resistant test:		
7 days at 250 ppm concentration	No cracks	

TABLE 9

INSULATION ELECTRICAL CHARACTERISTICS

SIGNAL CABLE

1. Insulation Resistance Constant:		
1000 feet at 15.6 degrees C (60 degrees F)	Minimum megohms	35,000
2. Electrical Stability in Water:		
1000 cycles 50 degrees C (122 degrees F)		
Dielectric constant 1 day immersion	Maximum	3.0
Increase in dielectric constant:		
1-14 days	Maximum percent	1.0
7-14 days	Maximum percent	0.5
Power factor		
14 days	Maximum percent	1.0
3. Accelerated Electric Stability in Water:		
80 volts/mil measurement stress		
60 cycles – 90 degrees C (194 degrees F)		
Dielectric constant -1 day immersion	Maximum	3.0
Increase in dielectric constant:		
1-14 days	Maximum percent	1.0

EXTERNAL SIGNAL CABLE
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7-14 days	Maximum percent	0.5
1-90 days	Maximum percent	1.0
Power factor		
14 days	Maximum percent	1.0
90 days immersion	Maximum percent	1.0
4. Accelerated Insulation Resistance Stability Test:		
90 degrees C (194 degrees F) megohms - 1000 feet		
1 day immersion	Minimum	1000
90 days immersion	Minimum	1000
5. Accelerated Voltage Stability		
Immerse 10-foot single conductor minimum No. 14 AWG with minimum 80 mils insulation in room-temperature water. Continuously energize without covering over insulation:		

Ac Voltage, V/Mil	Time, Mos.
325	2 or
280	3 or
240	4 or
200	6

TABLE 10

POLYETHYLENE PHYSICAL CHARACTERISTICS

When tested in accordance with methods described in ICEA S-95-658, the polyethylene compound to conform to the requirements in this table.		
1. Physical Properties:		
Original Requirements:		
Tensile strength	Minimum psi	1400
Elongation at rupture	Minimum percent	350

Aging Requirements:			
After 48 hour Air Oven at 100 degrees C (212 degrees F)			
Tensile strength	Minimum percent of unaged value	85	
Elongation at rupture	Minimum percent of unaged value	85	
Oil Immersion Aging: After 4 hours at 70 degrees C (158 degrees F), ASTM No. 2 Oil			
Tensile strength	Minimum percent of unaged value	75	
Elongation at rupture	Minimum percent of unaged value	75	
Mechanical Water Absorption : After 7 days at 70 degrees C (158 degrees F),			
Mg/Sq. In.	Maximum	5	
Shrinkback: 24 hours at 100 degrees C (212 degrees F)			
	Minimum percent	5	
2. Cold Bend:			
Mandrel size:	0-0.80	8 times outside diameter of cable	
	0.80 and over	10 times outside diameter of cable	
1 hour at minus 31 degrees F, Bend 180 degrees around mandrel		No cracks	
3. Heat Distortion: 1 hour in air oven at 194 degrees F			
Distortion	Maximum percent	25	
4. Absorption Coefficient: Reciprocal function of light transmission corrected for thickness.		Minimum 3200	
5. Environmental Stress Cracking Requirement Reagent Igepal CO-630:			
48 hours at 122 degrees F		No cracks	
6. Impact: 4 hours at minus 49 degrees F, strike with 1-inch diameter steel rod on a flat surface with 3 ft/lb force.			
Visual inspection		No cracks	

TABLE 11

PHYSICAL AND ELECTRICAL CHARACTERISTICS OF THE CPE JACKET

When tested in accordance with ICEA S-68-516 and UL requirements, the thermosetting chlorinated polyethylene jacket to conform to the requirements in this table.		
1. Physical Properties:		
Physical Requirements – Unaged		
Tensile Strength	Minimum psi (N/mm^2)	2000 (13.8)

Elongation at Rupture	Minimum percent	300
Tensile Strength, at 200% Elongation	Minimum psi (N/mm^2)	1400 (9.6)
Set	Minimum percent	50
Aging Requirements		
Air Oven Test at 121C for 168 Hours		
Tensile Strength	Minimum percent of unaged value	85
Elongation	Minimum percent of unaged value	70
Oil Immersion at 121C for 18 Hours (IRM 902)		
Tensile Strength	Minimum percent of unaged value	85
Elongation	Minimum percent of unaged value	70
2. Aging Requirements		
Air Oven Test at 100C for 168 Hours		
Tensile Strength	Minimum percent of unaged value	85
Elongation	Minimum percent of unaged value	65
3. Ozone Resistance		
After 24 hours at 0.015%		No Cracks
4. Cold Bend		
Minimum requirements after 1 hour at -35C		No Cracks
5. Gravimetric Water Absorption		
7 days at 70°C	Maximum mg/in^2 (mg/cm^2)	20 (3.08)
6. Tear Strength		
7 days at 70°C	Minimum Lbs/in (kgs/cm)	35 (6.25)
7. Flame Tests		
	VW-1 Flame Test	Passes
	IEEE-383-1974 Vertical Tray Test, completed cable	No Propagation
Oxygen Index	Maximum percent	30
8. Electrical Requirements		
Specific Surface Resistivity	Minimum megohms	200,000

TABLE 12

POLYVINAL CHLORIDE COMPOUND

PHYSICAL CHARACTERISTICS

EXTERNAL SIGNAL CABLE
34 42 40 – 44

When tested in accordance with methods described in ICEA S-95-658, the polyvinyl-chloride compound to conform to the requirements in this table.		
9. Physical Properties:		
Original Requirements:		
Tensile strength	Minimum psi	2000
Elongation at rupture	Minimum percent	150
Aging Requirements:		
After 168 hour Air Oven at 136 degrees C		
Tensile strength	Minimum percent of unaged value	75
Elongation at rupture	Minimum percent of unaged value	45
Oil Immersion Aging: After 40 days in oil at 75 degrees C, (IRM 902) ASTM No. 2 Oil		
Tensile strength	Minimum percent of unaged value	65
Elongation at rupture	Minimum percent of unaged value	65
Mechanical Water Absorption: After 7 days at 82 degrees C		
Mg/Sq. In.	Maximum	20
Shrink-back: 24 hours at 100 degrees C (212 degrees F)		
	Minimum percent	5
2. Cold Bend:		
Mandrel size:	0-0.80	8 times outside diameter of cable
	0.80 and over	10 times outside diameter of cable
1 hour at minus 31 degrees F, Bend 180 degrees around mandrel		No cracks
3. Heat Distortion: 1 hour in air oven at 121 degrees C 194 degrees F		
Distortion	Maximum percent	50
4. Absorption Coefficient: Reciprocal function of light transmission corrected for thickness.		Minimum 3200
5. Flame, Vertical Per UL 1581		Pass
6. Insulation Resistance in 75C water per UL83		Pass
7. Impact: 4 hours at minus 49 degrees F, strike with 1-inch diameter steel rod on a flat surface with 3 ft/lb force.		
Visual inspection		No cracks

TABLE 13

PROPERTIES OF CROSS-LINKED POLYOLEFIN SHEATH

1. Physical Properties:		
Original Requirements:		
Tensile strength	Minimum psi	1700
Elongation	Minimum percent	150
Aging Requirements:		
After 168 hour Air Oven at 100 degrees C		
Tensile strength	Minimum percent of unaged value	100
Elongation at rupture	Minimum percent of unaged value	75
After 168 hour Air Oven at 125 degrees C		
Tensile strength	Minimum percent of unaged value	75
Elongation at rupture	Minimum percent of unaged value	60
After 168 hour Air Oven at 150 degrees C		
Tensile strength	Minimum percent of unaged value	60
Elongation at rupture	Minimum percent of unaged value	60
8. Oil Immersion Aging: After 22 hours in oil at 125 degrees C, (IRM 902) ASTM No. 2 Oil		
Tensile strength	Minimum percent of unaged value	50
Elongation at rupture	Minimum percent of unaged value	50
9. Durometer	Shore A (ASTM D2240)	85 $\pm$ 5
10. Low Temperature Flex	Pass EC (ICEA S-19-81)	-40
11. Mechanical Water Absorption: After 168 hours at 70 degrees C		
Mg/Sq. In.	Maximum	30
12. Oxygen Index		
Percent of Oxygen	Minimum percent	35
13. Smoke Generation		
Flaming Average after 4 mins	Maximum optical density	150

Flaming Average	Maximum optical density	250
Non-Flaming Average after 4 mins	Maximum optical density	150
Non-Flaming Average	Maximum optical density	300
14. Ozone		Pass

4.01 MEASUREMENT

A. The work of EXTERNAL SIGNAL CABLE shall not be measured for payment.

4.02 PAYMENT

B. No separate payment shall be made for the work covered in this section. Payment for the Work of EXTERNAL SIGNAL CABLE shall be included in the contract lump sum price as shown in the Schedule of Prices for SIGNAL AND TRAIN CONTROL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

C. Signal and Train Control Work: 344200

END OF SECTION

SECTION 34 42 41
INTERNAL WIRE AND CABLE

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. The work to be done under this Section consists of furnishing and installing wire and cable inside relay houses, relay rooms or relay cases.

B. Related Sections:

1. 34 42 38 Miscellaneous Components and Products.
2. 34 42 39 Plug Connectors.
3. 34 42 40 External Signal Cable.
4. 34 42 60 Relay Houses.
5. 34 42 61 Relay Rooms.
6. 34 42 64 Relay Cases.
7. 34 42 76 Grounding Equipment.
8. 34 42 91 Signal System Tests.

1.02 REFERENCES

A. Reference Standards:

1. Section incorporates by reference the latest revisions of the following documents (unless otherwise noted), or if standard is adopted by the Authority Having Jurisdiction, the latest revision adopted.
2. American Railway Engineering and Maintenance-of-Way Association (AREMA).
    a. AREMA Communications & Signals Manual of Recommended Practices (C&S Manual).
3. ASTM International (ASTM):
    a. ASTM B3, Standard Specification for Soft or Annealed Copper Wire.
    b. ASTM B33, Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes.
    c. ASTM B189, Standard Specification for Lead-Coated and Lead-Alloy-Coated Soft Copper Wire for Electrical Purposes.
    d. D3032 Standard Test Methods For Hookup Wire Insulation.
4. Insulated Cable Engineers Association, Inc. (ICEA).

a. ICEA S-95-658/NEMA WC 70, Non-Shielded power cables Rated 2000 V or Less.

5. Institute of Electrical and Electronics Engineers (IEEE).

a. IEEE 383, Standard for Qualifying Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations.

6. Millitary Specification (MIL).

a. MIL-W-81822, General Specification for Wire, Electrical, Solderless Wrap, Insulated and Uninsulated.
b. MIL-W-22759/ SAE-AS22759, Wire, Electrical, Fluoropolymer-Insulated, Copper or Copper Alloy.
c. MIL-W-81044 Wire, Electrical, Crosslinked Polyalkene, Crosslinked Alkane-Imidepolymer, or Polyarlyene Insulated, Copper or Copper Alloy.
d. MIL-W-81381 Wire, Electric Polyimide Insulated, Copper And Copper Alloy.

7. National Fire Protection Association (NFPA).

a. NFPA 70, National Electrical Code.

8. National Electrical Manufacturers Association (NEMA).

a. NEMA HP 100, High Temperature Instrumentation and Control Cables.
b. NEMA HP 100.2, High Temperature Instrumentation and Control Cables Insulated and Jacketed with ETFE Fluoropolymers.

9. Society of Automotive Engineers International (SAE).

a. SAE AS22759, Wire, Electrical, Fluoropolymer-Insulated, Copper or Copper Alloy (supersedes MIL-W-22759, even though MIL-W-22759 is still widely referenced).

1.03 SUBMITTALS

A. The Contractor to submit the following plans and information for approval by the Authority:

B. Product Data:

1. Complete technical data verifying the proposed internal wire and cable complies with the requirements of this Section.

C. Procedures:

1. Field Installation, Inspection and Test Procedures.

D. Reports:

1. Reports of qualification tests witnessed by the Contractor.
2. Certified test reports of breakdown tests conducted on finished cable.
3. Certified test reports of flame tests conducted on finished cable.
4. Field Installation, Inspection and Test Report.

E. Samples:

1. Qualification samples for each wire and cable proposed.

1.04 QUALITY ASSURANCE

A. Follow quality assurance provisions of applicable standards in the manufacture of wire and cable covered by this Section.

B. All other work covered by this section to be performed in compliance with a Quality Assurance Program that meets the intent of ASQC C1-1996, General Requirements for a Quality Program.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Wire and cable to be properly crated at the manufacturer's point of shipment.

B. Wire and cable to be protected from damage throughout delivery, storage and handling.

C. Material damaged in transit or by mishandling or improper storage to be replaced by the Contractor at no additional cost to the Authority.

PART 2 - PRODUCTS

2.01 STRANDED AND WIRE

A. General Requirements

1. The requirements for wire specified in this Section to consist of this Section and SAE AS22759 or NEMA HP100 and NEMA HP 100.2.
2. Where there is a discrepancy between this Specification and the requirements of the applicable standard, the requirements of this Specification to govern.
3. The requirements of this Specification to also be used where the standard refers to “the detail specification.”

B. Internal Stranded Wire:

1. Conductor: Stranded Soft Annealed Copper per ASTM B3.
2. Coating: Tin or Lead per ASTM B33 or ASTM B189.
3. Insulation: Ethylene-Tetrafluoroethylene (ETFE) per SAE AS22759 or NEMA HP 100.2.
4. Construction: Per Table A.
5. Performance: Per Tables B and C.
6. Additional Requirements: Per Table F.

C. Identification:

1. Each stranded wire to be marked with the following information:

   a. Manufacturer's name.
   b. Year of manufacture.
   c. Size of conductor.
   d. Type of insulation.

2. Identifying markings to be permanent, legible and understandable.
3. Stranded wires used in multiconductor cable to be numbered or color-coded in addition to the basic four-part identification.

2.02 MULTICONDUCTOR CABLE

A. Outer Jacket: Thermoplastic rubber (TPR) in accordance with IEEE 383, stabilized for outdoor exposure.

B. Outer Sheath: Nominal thickness in accordance with ICEA S-95-658/NEMA WC70.

C. Barrier Tape: 0.005 inch thick; minimum 25 percent overlap.

D. Individual Conductors: Sized to meet 150 percent of the load requirements, minimum No. 16 AWG, with the exception of control panel internal wiring, which to be no smaller than No. 20 AWG.

E. Cables to be made by assembling individual or twisted pairs of insulated wires into a tight, cylindrical form. Individual or twisted pairs to be assembled helically and with adjacent layers wound in opposite directions.

F. Multiconductor cables specified in this Section to not exceed 37 conductors for vital circuits, or 50 conductors for non-vital circuits.

G. Spare Conductors:

1. Multiconductor cables to have spare conductors as indicated in these specifications.

2. Reduction in the number of spares is not allowed unless otherwise directed by the Authority in writing.

H. Identification:

1. The cable outer sheath to be marked with the following information, repeated at intervals no greater than 36 inches:

a. Manufacturer's name.
b. Year of cable manufacture.
c. Number and size of conductors.
d. Type of insulation in wires.
e. Type of outer sheath insulation.
f. Voltage rating.

I. Identifying markings to be permanent, legible and understandable.

2.03 SOLID WIRE FOR WIRE WRAP APPLICATION

A. General

1. The requirements for solid wire used in wire wrap application in this Section to consist of this Section and MIL-W-81822.
2. Where there is a discrepancy between this Specification and the requirements of the applicable standard, the requirements of this Specification to govern.
3. The requirements of this Specification to also be used where the standard refers to "the requirements of the applicable military specification sheet."

B. Solid wire:

1. Conductor: Soft annealed copper per ASTM B3 (Type A only).
2. Coating: Tin coating, continuity and adherence per ASTM B33.
3. Insulation: Ethylene Tetrafluoroethylene (ETFE), or Polyvinylidene Fluoride (PVF2).
4. Construction and Performance: Per Tables D and E.
5. Identification:

a. Each solid wire to be marked with manufacturer's name and type of insulation.
b. Information to be repeated at intervals no greater than 24 inches.
c. Identifying markings to be permanent, legible and understandable.

2.04 SOURCE QUALITY CONTROL

A. Testing Notification:

1. Notify the Authority in writing a minimum of ten days in advance of final testing, so that the Authority may witness tests if it so elects.

B. Contractor Inspection:

1. Witness and report results of each required qualification test.
2. Retain one half of each qualification sample for Contractor's evaluation and submit remaining one half to the Authority for final approval.
3. Monitor manufacturer's conformance to quality assurance requirements.

C. Authority Inspection and Testing:

1. The Authority reserves the right to audit conformance to specified witnessing and testing.

D. Multi-Conductor Cable Tests:

1. Test individual conductors per the specified requirements for Stranded Wire for General Use, before cable assembly.
2. Place finished cables in water at room temperature.
3. After 48 hours immersion and while still immersed, test all conductors for breakdown at 2,500 V (rms) for 5 minutes.
4. From each batch of cable outer-sheath material, flame-test samples of finished cable per IEEE Standard 383.

E. Stranded Wire Tests:

1. Flame Spread Test: UL 1581.
2. Vertical Flame Test: IEEE 383.
3. Dynamic Cut-Through Test: ASTM D3032.

    a. Perform at room temperature using tensile testing machine equipped with recorder suitable for recording force in pounds necessary to force a tungsten carbide cutting tool through insulation of a finished wire specimen.
    b. Cutting tool to have a cutting edge of 0.005-inch radius of curvature on a 90-degree wedge.
    c. Testing machine to also be equipped with a 12-volt detection circuit designed to stop testing machine when the cutting edge cuts through the wire insulation and contacts conductor.
    d. Remove 1 inch of insulation from one end of an 18-inch finished-wire specimen.

e. Place specimen on a hard, flat surface and orient cutting edge perpendicularly to axis of wire specimen.
f. Force cutting edge through insulation at a constant rate of 0.2 inch per minute until contact with the conductor occurs.
g. Record force measured at time of contact with conductor.
h. Perform four tests on each specimen with specimen being moved forward 1-inch minimum and rotated clockwise 90 degrees between each test.
i. Cut-through resistance to be average of four test result values.

2.05 MISCELLANEOUS PRODUCTS

A. Wire and cable tags:

1. See Miscellaneous Components and Products Section in these Specifications.

PART 3 - EXECUTION

3.01 WIRE AND CABLE SIZE REQUIREMENTS

A. Single conductor No. 14 stranded to be used for interconnecting signal junction boxes and lamp compartments and other miscellaneous equipment.

3.02 GENERAL WIRE AND CABLE REQUIREMENTS

A. Internal wire and cable to be installed in accordance with applicable recommended instructions of AREMA C&S Manual Part 10.4.1, Recommended Instructions for Wire and Cable Installation and Maintenance, and as specified.

B. Install wires and cables in a neat, workmanlike manner.

C. There to be no point-to-point redundancy of wires allowed for increased current capacity.

D. Terminating:

1. Leave sufficient slack in wire and cable to permit wire ends to be easily removed from the device or terminal and reterminated.
2. Terminate all spare conductors unless otherwise directed by the Authority in writing or if otherwise specified.

3.03 INSTALLATION IN TRAYS AND TROUGHS

A. Lay cable in trays or troughs; it to not be pulled into place.

B. Install with minimum crossovers and without pulling cable tightly around bends.

C. Leave sufficient slack in wire and cable at transitions and other locations to prevent damage to the wires and cables over time due to abrasion.

D. Protect exposed wires and cables entering or leaving equipment racks or housings from abrasion by sharp metallic edges.

3.04 BUNDLING AND CABLING

A. Provide nylon straps for bundling and cabling conductors where two or more single conductors are exposed in internal rack bundles, cable trays or cable troughs, or whenever wires are bundled.

1. Tape to not be used for this purpose.
2. Install straps a minimum of every 5 feet along cable run.
3. Train wires of multi-conductor cables exposed for termination by stripping cable jacket in a neat, workmanlike manner and tie approximately every 3 inches with nylon straps.

3.05 MODULE WIRING

A. Unless otherwise approved by the Authority in writing:

1. Provide solderless connections.
2. Provide solid wire for wire wrap connections.
3. Provide stranded wire for crimped connections for module and display panel wiring.
4. Minimum wire size:

a. Stranded: No. 20 AWG.
b. Solid: No. 24 AWG.

3.06 RACK WIRING

A. Vital and non-vital rack wiring:

1. Provide approved solderless connections.
2. Wire: Stranded, minimum No. 16 AWG, or multiconductor cable, unless otherwise directed by the Authority in writing.

B. Neatly tie rack wiring into compact bundles:

1. Secure main bundles and branches to racks.
2. Prevent physical damage due to pressure or abrasion.
3. Prevent wire weight from being supported by wire terminations, connections, or plug connection.

4. Wire bundles and cables to not interfere with visual inspecting, troubleshooting, or repair of rack mounted equipment.

3.07 RACK-TO-RACK WIRING

A. Route rack-to-rack wiring via overhead cable trays with 1 foot of slack between cable tray and each rack to which cable or wire is connected.

B. Conductor size: Minimum No. 16 AWG.

C. Vital Racks:

1. For rack-to-rack wiring in factory wired housings and relay rooms, use single conductors tied into bundles to form unjacketed multi-conductor cables, unless otherwise approved by the Authority in writing.
2. Maximum tie spacing: 6 inches.

D. Non-Vital Racks:

1. Provide single conductor cables and solderless terminals for rack-to-rack wiring, unless otherwise approved in writing by the Authority.
2. Non-vital panels within the relay rooms and towers may have a plug connector panel to terminate wiring from rack.
3. Non-vital racks within the relay houses to be wired point-to-point without the use of plug connectors.

E. Non-Vital Racks to Vital Racks:

1. Provide single conductors tied into bundles for wiring between non-vital and vital rack connection points, unless otherwise approved in writing by the Authority.
2. Wiring between relay room and tower racks may have a plug connector panel to terminate the wiring between racks.
3. Racks within relay houses to be wired point-to-point without using plug connectors.
4. Maximum tie spacing: 6 inches.

F. Rack to Local Control Panel:

1. Provide made-up cables and multi-conductor cables from vital and non-vital instrument racks to solderless terminals installed on Local Control Panel.
2. Made-up cables:

a. Single conductors, minimum No. 16 AWG stranded.

b. Bundle tie spacing: Maximum 6 inches.

G. Control Panel Wiring:

1. Use single conductor wires and solderless terminals, unless otherwise approved in writing by Authority.
2. Minimum size: No. 20 AWG.

H. Entrance to Instrument Rack Wiring:

1. Wiring from entrance racks to instrument racks:

a. Stranded wire.
b. Size: Minimum No. 16 AWG, as approved by the Authority.

I. High Voltage Wiring:

1. Internal wire to meet requirements of the External Signal Cable Section of these specifications, where used in circuits directly connected to rails and in circuits above 600 V.

J. Energy Distribution:

1. Unless otherwise approved by the Authority in writing:

a. Wire for energy distribution: Single conductor stranded wire.
b. Rack wiring:

i. Stranded wire, minimum No. 10 AWG.
ii. Solderless connections.

c. Rack-to-rack wiring.

i. Stranded wire, minimum No. 10 AWG.
ii. Solderless connections.

K. Conductor Sizing:

1. Size conductors per NFPA 70, but not smaller than minimum specified conductor sizes.

L. Identification:

1. Cables:

a. Provide a cable tag for each cable.
b. Letter tags with cable destination and number of conductors in cable.

2. Conductors:

a. Identify individual conductors at each cable termination with wire tags.
b. Identify each spare conductor in each cable.

3.08 FIELD QUALITY CONTROL

A. Inspection:

1. After installing, inspect each wire and cable installation in accordance with requirements of Contractor's approved Field Installation, Inspection and Test Procedure.
2. Correct noted deficiencies to the satisfaction of the Authority.

B. Test cable in accordance with the Signal System Tests Section of these Specifications and the Contractors approved Field Installation Inspection and Test Procedure.

3.09 INTERNAL WIRE AND CABLE TABLES

TABLE A: Construction Details

Wire Size (AWG)	Conductor Stranding (Strands X Size)	Max. Dia. Stranded Conductor (Inches)	Conductor Resistance Max. at 20 C (Ohms/1000 Ft.)
20	19 x 32	.041	9.88
16	19 x 29	.058	4.81
14	19 x 27	.073	3.06
12	37 x 28	.090	2.02
10	37 x 26	.114	1.26
8	133 x 29	.173	.701

TABLE B: Performance Details

ABRASION RESISTANCE (Procedure 11)				
Wire Size (AWG)	**Min. Resistance (Inches of Tape)**	**Weight Support Bracket**	**Weight (Pounds)**	**Tension Load (Pounds)**
20	26	A	1.0	1.0
16	28	A	1.0	2.0

14	19	B	3.0	2.0
12	29	B	3.0	2.0
10	36	B	3.0	3.0
8	35	B	3.0	3.0

TABLE C: Performance Details

BEND TESTING				
Wire Size (AWG)	**Mandrel Diameter Life Cycle**	**Cold Bend (Inches Max.)**	**Test Load Life Cycle**	**Cold Bend (Pounds)**
20	3/4	1	2.0	4.0
16	1	1-1/4	2.0	5.0
14	1-1/4	2	2.0	5.0
12	2	2	2.0	5.0
10	3	3	2.0	5.0
8	3	4	3.0	6.0

TABLE D: Construction and Performance Details

Wire Size (AWG)	**Finished Wire Diameter (Inches)**	**LOAD IN GRAMS FOR**		**Insulation Pull-Off Cold (Pounds)**
		Cut-Through	**Flow**	
24	0.034±.0015	1050	800	1 to 4
22	0.039±.002	1100	850	1 to 6
20	0.046± .002	1200	950	1 to 6

TABLE E: Construction and Performance Details

Wire Size (AWG)	**BEND MANDREL DIAMETER (IN.)**		**Testing Tension Load (lbs.) Cold Bend**
	Heat Resistance	**Cold Bend**	
24	7/64	1.0	0.50
22	1/8	1.0	0.75
20	9/64	1.0	0.75

TABLE F: Additional Requirements for Stranded Wire

Type of Insulation	ETFE	Polyarylene	Polyimide film tape
Military Specification	MIL-W-22759	MIL-W-81044	MIL-W-81381
Nominal Wall Thickness Size 20-14 AWG	15 mils	10 mils	10 mils*
Nominal Wall Thickness Size 12-8 AWG	20 mils	12.5 mils	12.4 mils*
Temperature Rating	150 C	150 C	150 C
Blocking (Qualification only)	200°C	200°C	200°C
Color	Contractor's Option		
Flammability**	Pass	Pass	Pass
Identification**	30-inch intervals (max.)		
Identification, Striping, or Printing Durability	125 cycles (250 strokes) (min.) with 500 grams weight		
Life Cycle Dielectric Test	Oven temp. 200°C for 168 hrs. 2200 volts (rms), 60 Hz		
Accelerated Aging	7 hrs. at 210°C (Quality Conformance Test, Group II; Procedure as in Life Cycle Test)		
PHYSICAL PROPERTIES OF INSULATION			
Tensile Strength PSI (min.)	5,000	12,000	24,000
Elongation percent (min.)	125	50	40
Chemical Resistance	Test not required		
Shrinkage at 200± 2°C, inches (max.)	0.125	0.125	0.303
Smoke	200°C	200°C	200°C***
Thermal Shock	Test not required		
Cold Bend	-65°C	-65°C	-65°C
Wrap Test (Size 20 AWG Wire)	2 hrs. at 200°C No Cracks	Mandrel Dia. .125 Inches No Cracks	

Dynamic Cut Through** pounds (min.) at 23°C with size 20 AWG	90	90	90
Wicking	Test not required		
Abrasion Resistance after Immersion	Same as initial		
*Nominal wall thickness for Polyimide film to be achieved by following combinations of 50 percent overlapped tape wraps plus an outer 1 mil coating of modified aromatic Polyimide resin: First wrap 1/2/.5 Second wrap .5/1/.5 Third wrap (Size 12-8 AWG only) .1/1/.1			
Lamination Sealing	NA	NA	230°C
Polyimide Cure Test	NA	NA	48 hrs. req'd.
Resin Coating Durability	NA	NA	****
Humidity Resistance	IR after exposure to meet initial requirements		
Voltage Rating	600V RMS	600V RMS	600V RMS
Impulse Dielectric Test (100%)	8 KV Peak	8 KV Peak	8 KV Peak
Insulation Resistance	5000 megohms per 1000 ft. (min.)		
Spark Test	Test not required		
Surface Resistance, megohms/ inch (min.) Initial and Final	500	500	500
Wet Dielectric Test volts (rms)	2500	2500	2500
** As required by this Specification	***Test per MIL-W-22759		
**** 250 cycles (500 strokes) (minimum) with one pound load			

TABLE G: Additional Requirements for Solid Wire

Temperature Rating	200°C maximum conductor temperature

Voltage Rating	300 volts (rms)
Insulation Tensile Strength	2500 psi (minimum)
Insulation Elongation	50% (minimum)
Color	Black
Spark Test	3000 volts (rms)
Insulation DC Resistance	**2500 megohms/1000 ft. (minimum)**
Wet Dielectric Test	2000 volts (rms), 60 Hz
Cold Bend Conditioning	4 hours at -65 ± 2°C
Dielectric Test for Cut-Through and Cold Flow	500 volts (rms), 60 Hz
Insulation Heat Resistance	Conditioning, 120 hours at ± 2°C shrinkage, 0.062 inch (max.)
Dielectric Constant	2.30 maximum at 1 MHz
Power Factor	0.0005 maximum at 1 MHz
Resistance to Fluids	Test not required
Flammability	30 sec. (maximum) after-flame 3.0 inches (maximum) flame travel. No flaming of tissue paper.
Surface Resistance	5000 megohms (minimum)

PART 4 - MEASUREMENT AND PAYMENTMEASUREMENT

A. The work of INTERNAL WIRE AND CABLE shall not be measured for payment.

4.02 PAYMENT

B. No separate payment shall be made for the work covered in this section. Payment for the Work of INTERNAL WIRE AND CABLE shall be included in the contract lump sum price as shown in the Schedule of Prices for SIGNAL AND TRAIN CONTROL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

C. Signal and Train Control Work: 344200

END OF SECTION

SECTION 34 42 62
JUNCTION BOXES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Furnishing and installing junction boxes for terminating signal and signal power cables, track circuit cables, express signal cables, and switch-and-lock-movement layouts.
2. Cable cord connectors.

B. Related Sections:

1. 34 42 11 Power Switch & Lock Movement Layouts.
2. 34 42 19 Reverse Running Warning Light Layouts.
3. 34 42 20 Audio Frequency Track Circuits.
4. 34 42 21 Power Frequency Track Circuits.
5. 34 42 38 Miscellaneous Components and Products.
6. 34 42 40 External Signal Cable.

1.02 SUBMITTALS

A. Before ordering, fabricating, or assembling equipment, submit the following for approval by the Authority:

1. Product Data:

a. Each type and size of junction box, including components furnished with each.
b. Paint and protective coating proposed for identification.

2. Shop Drawings:

a. Drawings of each type of junction box including terminal boards, signal terminal binding posts, wiring, mounting details, and other integral parts.
b. Where junction box forms part of layout, junction box submittal may be made as part of total layout submittal.
c. Drawings showing location of each junction box.
d. Drawings showing design of support system and method of installation for each junction box.

3. Procedures:

a. Factory Test Procedure including verification of NEMA 4X rating.
b. Installation Inspection and Field Test Procedure.

PART 2 - PRODUCTS

2.01 JUNCTION BOX GENERAL REQUIREMENTS

A. Size to accommodate specified signal terminal binding posts, terminal boards, cable, wire identification, termination of spare wires, and other associated apparatus along with required expansion space.

1. The size is to be 25% larger than what is required to house the as designed equipment and cabling.
2. A minimum of 10% spare terminals are to be included.
3. The enclosure is to be sufficient size to provide ample space for the bending radii of the cables and wires.

B. Provide with gaskets to prevent the entrance of moisture and dust, in accordance with AREMA C&S Manual 15.2.10, Recommended Functional Guidelines for Gasket Material Suitable for Circuit Controllers, Signal Cases, and Other Signal Apparatus Housings.

C. Provide NEMA 4X rated enclosures.

D. Provide with print pocket capable of holding 24 inch by 36 inch folded plans.

E. Finish and Painting.

1. Exterior: Stainless steel junction boxes.

a. To not be painted unless otherwise directed by the manufacturer and approved by the Authority.

2. Exterior: Cast junction boxes.

a. Paint junction boxes in accordance with the Miscellaneous Components and Products Section of these Specifications.
b. Switch-and-lock -movement-layout junction boxes: Black.
c. Signal and communication junction boxes: Gray.

3. Interior: Cast junction boxes.

a. Finish and painting of specified junction boxes to be manufacturer's standard.

F. Security.

1. Provide each junction box with a locking device and a split 1/2-inch hex Raco-style barrel lock with brass chain. Chain to be fastened to the side of the box with enough slack to allow for insertion and locking of the barrel lock in the locking hasp.

2.02 TRACK CIRCUIT, AF LOOP, ROUTE SELECTORS, AND LOCAL CABLE JUNCTION BOXES (CASR ALUMINIUM)

A. Material: Cast aluminum.

B. Hinge and hasp fittings.

1. Aluminum boxes: Aluminum.

C. Size to fit under platform edge and not extend into train clearance envelope.

D. Provide each box with number of accesses required for cable and conduit.

E. Provide complete with the following:

1. Signal double-post terminal binding posts as specified in the Miscellaneous Components and Products Section of these Specifications.

F. Acceptable Manufacturer:

1. Alstom (GRS).
2. Ansaldo STS (US&S).
3. Approved equal.

2.03 SWITCH-AND-LOCK-MOVEMENT JUNCTION BOXES (CAST IRON)

A. Provide a junction box at each switch-and-lock movement for termination of switch machine and electric lock cables, as specified in the Power Switch & Lock Movement Layouts, the Electric Lock Layouts, and the Hand Operated Switch Machines and Layouts Sections of these Specifications.

B. Material: Cast-iron.

C. Hinge and hasp fittings.

1. Cast-iron boxes: Bronze

D. Provide each box with number of accesses required for cable and conduit.

E. Provide complete with the following:

1. Signal double-post terminal binding posts as specified in the Miscellaneous Components and Products Section of these Specifications.

2. Security: Provide with means of attaching a padlock to prevent access.

F. Acceptable Manufacturer.

1. Alstom (GRS).
2. Ansaldo STS (US&S).
3. Approved equal.

2.04 ROOM TO ROOM, EXPRESS CABLE (STAINLESS STEEL)

A. Provide signal junction boxes to terminate signal cables complete with signal terminal binding posts.

B. Material: 316L stainless steel 12 gauge (minimum) for enclosure, doors, hinges, and all accessories attached to the box. Door latching mechanism to be made of minimum of 10 gauge stainless steel, u-channel bracket with rollers.

C. The signal junction boxes to conform to NEMA 4X and U.L. requirements.

D. Each junction box to be sized to permit the termination of all line circuit, track circuit and supervisory express cables within the box, including all spare wires. See the External Signal Cable Section of these Specifications for more information.

1. The size is to be 25% larger than what is required to house the as designed equipment and cabling.

E. Enclosure sizes to be sized to fit all the necessary signal terminal binding posts and cable as required and a print pocket.

F. Hinges to be the full length of the door and welded to the enclosure.

1. The enclosure design to include complete hinge concealment when the door is closed.
2. A door to be capable of opening through a 180-degree swing, and equipped with a removable stop to prevent it from closing or opening further when in the 90 degree and 170 degree positions.
3. The door design to be of a tamperproof construction.
4. If the door surface area is greater than 400 square inches, it to incorporate stainless steel bracing to prevent door buckling or warping.

G. All mounting brackets to be welded on outside of box.

1. Riveting, bolting, and any other method requiring piercing of the box is not allowed.

H. A ½" breather drain that maintains the NEMA 4X rating of the enclosure to be installed at the bottom of the box.

1. Breather drain to be made of same stainless steel alloy as the main box.

I. The enclosure door to have a stainless steel 3-point locking mechanism for padlocking the enclosure.

1. The latch to have a 5/8" diameter opening for accepting a CTA lock shackle.
2. The latch and handle to be made of 316L stainless steel.
3. Stainless steel reinforcing pads to be provided where the locking mechanism is attached.
4. Door to have rolled edges.

J. Each enclosure to have a stainless steel drip shield installed to protect the door hardware from dripping water, ice/snow buildups, and settling dust.

1. The drip shield to be welded to the main box.

K. The enclosures to be of sufficient size to provide ample space for the bending radii of cables and wires.

L. All cable wires brought into the junction box to be terminated on signal terminal binding posts mounted to stainless steel support rails.

M. A minimum of 10% spare terminals to be provided in each junction box.

N. There to be a minimum of 6" spacing between terminal blocks.

O. There to be a minimum of 8" space between the inner walls of the junction box and any terminal block.

2.05 MISCELLANEOUS PRODUCTS

A. Cable cord connectors: Water and oil-tight type.

PART 3 - EXECUTION

3.01 REQUIRED JUCTION BOXES

A. Provide junction boxes at each block location between interlockings for terminating the following cables:

1. Local track circuit cables.
2. Track circuit express cables.
3. Line circuit express cables.

B. Provide junction boxes for local track circuits and audio loops to terminate cables, as required by the final design.

C. Provide junction boxes for route selector and switch-and-lock-movement layouts to terminate cables. Route selector junction boxes are defined as the terminal cases contained within the split-base junction boxes that are part of the respective mounting and support assemblies. Junction boxes associated with switch and lock movement layouts are defined as cast steel terminal cases.

D. Provide signal junction boxes to terminate signal and worker ahead cables. These to be split-base junction boxes that are integral to the respective signal mounting and support assemblies.

3.02 JUNCTION BOX INSTALLATION

A. Provide junction boxes complete with required mounting hardware.

B. Mast mount cable junction boxes (outdoor areas).

C. Provide foundations and attachment hardware for mounting cable junction boxes in ballasted areas.

D. Design support system for installation in closed deck areas and submit for approval before fabrication.

E. Locations of junction boxes under platform areas are subject to approval by the Authority.

3.03 CABLE TERMINATION

A. Express signal cables: Terminate in each junction box at each block location.

B. Conduit connectors to firmly support terminated conduit end.

C. Where conduit is used as ground connection, provide grounding type connections for the conduit termination.

3.04 PAINTING

A. Following completion of installation and testing, paint cast junction boxes in accordance with the Miscellaneous Components and Products Section of these Specifications.

3.05 IDENTIFICATION

A. The contractor to weld black powder coated stainless steel lettering of 2” in height onto the outside of the JB door indicating the approved name designation of the junction box. All lettering to be level with the top of the junction box door.

B. The top of each terminal strip to be clearly labeled with 1” black labeling. Labeling may be stenciled on the plywood after it is painted.

C. All wires terminating in the junction box to be tagged in accordance with the Miscellaneous Components and Products Section of these Specifications.

D. Protective coat: After application, protect with a coat of clear exterior grade varnish, acrylic, or equal transparent protective covering, compatible with paint used for stenciling.

3.06 FIELD QUALITY CONTROL

A. Inspection:

1. After installing and wiring, inspect each junction box in accordance with requirements of Contractor's approved Installation Inspection and Field Test Procedure.
2. Correct noted deficiencies to the satisfaction of the CTA.

4.01 MEASUREMENT

A. The work of JUNCTION BOXES shall not be measured for payment.

4.02 PAYMENT

B. No separate payment shall be made for the work covered in this section. Payment for the Work of JUNCTION BOXES shall be included in the contract lump sum price as shown in the Schedule of Prices for SIGNAL AND TRAIN CONTROL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

C. Signal and Train Control Work: 344200

END OF SECTION

SECTION 34 42 76
GROUNDING EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

B. The work to be performed under this Section consists of furnishing and installing a grounding and bonding system for relay houses, relay rooms, signal towers, wayside signals, and other signal apparatus including cases and junction boxes, as hereinafter specified.

C. Related Sections:

1. 34 42 15 Signal & Route Selector Layouts.
2. 34 42 17 Worker Ahead Signal System.
3. 34 42 18 Automatic Train Stops.
4. 34 42 35 Instrument Racks.
5. 34 42 36 Entrance Racks.
6. 34 42 37 Cable Trays.
7. 34 42 38 Miscellaneous Components and Products.
8. 34 42 40 External Signal Cable.
9. 34 42 41 Internal Wire and Cable.
10. 34 42 60 Relay Houses.
11. 34 42 61 Relay Rooms.
12. 34 42 62 Junction Boxes.
13. 34 42 64 Relay Cases.
14. 34 42 68 Control Panel House.
15. 34 42 70 Signal Power Distribution System.
16. 34 42 71 DC Power Supplies.
17. 34 42 72 Automatic Transfer Equipment.
18. 34 42 73 Signal Transformers.
19. 34 42 80 Operation Recorders.
20. 34 42 81 Non-Vital Processors.
21. 34 42 82 Control Panels.
22. 34 42 85 Vital Microprocessor Interlocking System.
23. 34 42 87 AVI System.
24. 34 42 91 Signal System Tests.

1.02 SUBMITTALS

A. Before ordering, fabricating, or assembling equipment, submit the following for approval by the CTA:

1. Circuit and schematic drawings showing grounding design details of:

a. Relay houses and ancillary equipment.
b. Relay rooms and ancillary equipment.
c. Towers and ancillary equipment.
d. Wayside signal control devices.
e. Junction boxes.
f. Cases and ancillary equipment.
g. Inverter racks.
h. Signal/commercial power racks.

1. Procedures for grounding of all equipment:

i. Installation Inspection Procedures.
j. Test Procedures.

1.03 QUALITY ASSURANCE

A. All grounding systems furnished and installed as herein specified to be inspected and any deficiencies noted to be corrected. The inspection to be conducted in conformance with the requirements of the Contractor's Installation Inspection Procedures as approved by the CTA.

B. The final tests of the grounding system to be in conformance with the requirements of theses Specifications and the Contractor’s Test Procedures as approved by the CTA.

1.04 DELIVERY, STORAGE, AND HANDLING

A. All equipment to be protected from damage throughout delivery, storage, and handling.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Ground rods and clamps to be as manufactured by Copperweld Corporation or an CTA approved equal.

1. Ground rods to be:

a. Eight feet in length.
b. At least five-eighths inch diameter.
c. Copper-clad steel, non-rusting, sectional type.

Up to three sections can be added to achieve fifteen Ohms or

less resistance to ground.

2. Ground clamps to be:

a. Cast bronze clamp body with non-ferrous set screws.

A. A ground buss of nickel-plated hard drawn pure copper to be provided in each of the following locations with the following minimum requirements:

3. Locations:

a. Relay house.
b. Relay room.
c. Wayside case.

4. Minimum ground buss requirements:

a. Ground buss bar - relay houses, rooms and towers:

Two inches high by one-half inch thick running entire length of relay racks.

Bar to be mounted completely insulated from house, room and tower structures.

Bar to be freely accessible and mounted at approximately overhead cable tray height.

Equipment racks to be isolated; from each other, the house, room and tower structure and wire chase trays.

Individual ground wires to be run from each rack to the ground buss bar.

Grounding requirements within an equipment rack to be run to the racks ground stud with the exception of ground detector reference grounds that to be run to a ground separate from the locations ground grid.

The ground buss bar to have two separate ground connections to the house or., room primary ground studs.

b. Ground buss plate – wayside cases:

i. Eight inches high by eight inches long by one-half inch thick.

Twelve, three-eighths inch holes drilled and tapped in the buss and twelve, three-eighths by one and one-half inch long hex head nickel plated bronze studs with one washer and flat nut each to be installed.

Mount ground buss plate to case backboard.

Connect ground buss plate to case ground stud.

B. Lugs for attachment of ground wire to the equipment to be in accordance with the Miscellaneous Components and Products Section of these Specifications.

C. Bolts for ground wire attachment to be nickel plated bronze.

1. There to be no more than one ground wire per bolted connection.

D. External and internal ground wire to be in accordance with the External Signal Cable and Internal Wire and Cable Sections of these Specifications.

PART 3 - EXECUTION

3.01 GENERAL

A. Ground connection between the neutral conductors of the Power Company and AC signal supply system to not be permitted.

B. Grounding to conform to National Electrical Code unless otherwise stated herein.

C. Minimum resistance to ground to be fifteen Ohms or less.

D. Equipment located:

1. In ballast to be grounded using a #6 AWG stranded bare copper conductor.
2. In subways, on elevated structures and on concrete decks, equipment to be grounded using a #6 AWG stranded copper conductor insulated with green EPR insulation.

E. Grounding conductors to be:

1. Run freely, not stretched, and with no sharp bends.
2. Kept as short and direct as possible.
3. Run so not to cause snag or tripping hazard.
4. Run in an FRE conduit between the wayside device and ground point.

F. Ground rods to be:

1. Driven a sufficient distance below finished ballast or covered so that identification of ground rod is clear, so as to prevent a tripping hazard.
2. Driven in undisturbed compacted earth outside of the area of excavation for the wayside device or structure.

G. Ground connections:

1. In ballast:

a. Each wayside signal device to be provided with its own separate ground. Grounding more than one wayside device to a common ground rod will not be allowed.

2. In areas where ground rods cannot be utilized:

a. Each wayside signal device to be run and connected to a ground point separate from other equipment.

i. On elevated steel structures, grounds to be made by electrically bonding the ground wire to the structure using an arc weld. Only a single wire connection will be allowed per weld.

Prior to welding to the rail or the structure, the surface where the bond is to be applied to be ground clean with a reinforced grinding wheel to prevent any foreign materials such as scale, grease, rust, and paint, from being fused into the weld.

At an ambient temperature of 30 degrees F or less, the surface to be heated with a flame heat source to a temperature between 60 and 100 degrees F.

Welds to be made in one continuous pass with voltage settings of 22 to 24 volts and 170 to 200 amps for fast moving single pass flat welds.

After the connection has been tested, the area of the structure to be re-primed and repainted in accordance with Steel Structures Painting Council PS-10.

On concrete deck and in subway tunnels where metallic structure is available for grounding purposes.

(a) Reference G.2.a.i above.

On concrete decks where metallic structure is not available for grounding purposes.

(a) A ground connection in the signal room or elsewhere to be established by the Contractor specifically to ground wayside equipment at the interlocking.

This ground connection or connections to be independent of any other signal grounding.

There to be no tie point between signal room grounding and wayside equipment grounding except through the earth itself.

When grounds cannot be made to the deck's steel reinforcement, a 250MCM ground buss cable to be run to the outside of the interlocking, the approximate length of the interlocking, and approximately two feet up on the sound wall.

The cable to be run in FRE conduit fastened to the wall with clamps and epoxy anchors.

At each end of the cable to be a solid copper buss bar a minimum of one-half inch thick. The bars to be anchored to the wall and isolated.

Each end on the 250MCM ground grounding cable to be connected to the buss bars.

The opposite end of the buss bars to be connected to 250MCM cables, run in FRE conduits to the ground connection established by the Contractor.

The copper buss bars to be of sufficient length to accept a single ground connection from each piece of signal equipment within the area.

Connections made to ground buss bars to be mechanical.

Ground buss bars and connections to be shielded with a fiberglass cover.

Detailed grounding method(s) to be submitted to the CTA for approval.

3. Wayside signal cases housing signal equipment (other than cable terminations) to be provided with two ground connections.
4. Signal equipment enclosures housing ground detectors to be provided with one additional ground rod and connection for ground detector cross check circuitry.
5. Signal houses and rooms to require a minimum of four ground rods, one at each corner of the enclosure.

    a. The rods to be connected together forming a grid around the signal enclosure.
    b. The signal enclosure to be tied to the grid at one corner of the near and far ends.
    c. The ground conductors forming the grid to be buried a minimum of twelve inches below the surface of the earth beneath the ballast.
    d. Signal houses located on structures to be isolated from the structure and earth grounded.

i. Structure railings and flooring to be made of insulating material so personal cannot come into contact with signal house and the structure at the same time.

3.02 INVERTER POWER RACKS

A. Grounding requirements in ballasted track, on elevated structures and concrete decks are as follows:

1. The inverter rack supports the inverter cabinet and all high voltage 600 VDC equipment.
2. Inverter power racks to be isolated from earth and the rack and all its equipment maintain a minimum of six feet separation from any potentially earth grounded device or object.
3. Inverter racks to be grounded to a -600 VDC running rail using two, #2/0 AWG stranded bare copper insulated cables.
4. Cables to be individually welded approximately six inches apart to the rail and tagged “-600 VDC INVERTER CONNECTION”.
5. The opposite ends of the -600 VDC cables to be mechanically connected (1) to the ground buss in the inverter cabinet and (2) to the rack ground stud. A jumper same as the -600 VDC cables to be installed between the inverter ground buss and the rack ground stud and mechanically connected.

3.03 SIGNAL / HOTEL POWER RACKS

A. Grounding requirements in ballasted track, on elevated structures and concrete decks are as follows:

1. Two ground rods to be driven into the earth. One on each side of the power rack. Where ground rods cannot be driven follow methods previously noted in this specification.
2. Ground rods to be driven in undisturbed compacted earth outside of the area of excavation for the rack.
3. Top of installed ground rods to be at a minimum depth of six inches below the finished grade of the ballast.
4. Cable between the relay rack ground bolts (one each side) and earth ground connections to be:

   a. In ballasted areas, No. 6 AWG stranded bare copper.
   b. On elevated structures, concrete decks and in subways, No. 6 AWG stranded copper with green EPR insulation.

5. In ballasted areas only, two additional No. 6AWG stranded bare copper cables to be run, one from each ground rod to the nearest ground rods of the signal

house ground thus completing the house grounding grid. These cables to be buried twelve inches below the earth's surface below the ballast.

3.04 INTERNAL EQUIPMENT GROUNDING

A. The control panel to be grounded with a separate insulated No. 6 AWG solid soft drawn copper wire connected to the prime ground buss.

B. Equipment chassis to be grounded to racks in which they are mounted in accordance with the manufacturer's recommendations.

C. Each instrument rack and entrance rack in the relay houses and rooms to be grounded to the prime ground buss.

1. Each rack to be connected to a grounding buss bar by means of a separate copper connection.
2. Grounding studs to be provided on both the grounding buss bar and each rack to allow for easy individual disconnection of any rack from the grounding system.
3. Each grounding buss bar to be directly connected to the prime ground buss by means of No. 6 AWG copper connector without any intermediate termination.
4. Individual racks to be electrically isolated from every other rack with the exception of the connection to the main grounding buss. Racks may not be directly electrically connected to one another.

D. A prime ground buss bar, equipped with sufficient facilities to make all the grounding connections specified, to be furnished and installed in each relay house, relay room, and relay case.

1. Where existing electrical equipment rooms contain a prime ground buss, the Contractor to connect the signal prime ground buss bar by means of a No. 6 insulated wire between the buss bar and the electrical equipment room prime ground.

    a. The Contractor to install all necessary conduits, for protection of the No. 6 ground connection, between the two buses.

2. The grounding buss bars to be mechanically and electrically attached to all cable trays within the houses and rooms.
3. The bars as installed to be free from sharp edges.
4. The grounding bars to be connected to the prime ground buss bar with a No. 6 AWG wire.

3.05 TESTS

A. The Contractor to test grounding of equipment in accordance with approved installation and operating test procedures.

4.01 MEASUREMENT

A. The work of GROUNDING EQUIPMENT shall not be measured for payment.

4.02 PAYMENT

B. No separate payment shall be made for the work covered in this section. Payment for the Work of GROUNDING EQUIPMENT shall be included in the contract lump sum price as shown in the Schedule of Prices for SIGNAL AND TRAIN CONTROL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

C. Signal and Train Control Work: 344200

END OF SECTION

SECTION 34 42 90
TECHNICAL SUPPORT

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. The work to be performed under this Section consists of furnishing the following technical support and material:

a. Maintenance and trouble-shooting manuals and training of the CTA's technical maintenance and engineering personnel. Training content and schedule to consider personnel on second and third shifts.

b. Training aides and SOPs and instruction of the CTA's Rail Operations and Control Center personnel. Training content and schedule to consider personnel on second and third shifts.

c. Certain items of maintenance equipment designated as GROUP 1 EQUIPMENT, as herein specified.

d. Preparation of a supplemental list of recommended support materials designated as GROUP 2 SUPPORT MATERIALS that the Contractor and the CTA consider essential to maintaining the Signal & Train Control System.

e. The GROUP 2 SUPPORT MATERIALS list of items is to be comprehensive and representative for maintaining all elements of the signal system. Each item on the list to include the Contractor's:

Apparatus tabulation number.
Manufacturer's reference number.
Recommended quantity, unit price, and failure probability.
The CTA to determine the final quantities of materials to be furnished, utilizing a bid cost-amount included under this Contract for GROUP 2 SUPPORT MATERIALS.
Documentation, including price lists and actual purchase invoices to substantiate unit prices, for all GROUP 2 SUPPORT MATERIALS furnished.
Certain items designated as GROUP 2 SUPPORT MATERIALS, as herein specified. These items to be furnished utilizing a bid cost-amount included under this Contract, without any additional cost, profit or markup.

f. A supplemental list, designated as GROUP 3 SUPPORT MATERIALS, for apparatus over and above that designated for GROUP 2. The GROUP 3 list will be evaluated by the CTA for separate, or change order procurement.

B. Related Sections:

1. 34 42 01 Basic Signal Technical Requirements.
2. 34 42 11 Power Switch and Lock Movements.
3. 34 42 15 Signal and Route Selector Layouts.
4. 34 42 18 Automatic Train Stops.
5. 34 42 20 Audio Frequency Track Circuits.
6. 34 42 21 Power Frequency Track Circuits.
7. 34 42 23 Impedance Bond Layouts.
8. 34 42 30 Relays.
9. 34 42 38 Miscellaneous Components and Products.
10. 34 42 50 Snow Melter Layouts.
11. 34 42 51 Snow Melter Cases.
12. 34 42 70 Signal Power Distribution Systems.
13. 34 42 71 DC Power Supplies.
14. 34 42 72 Automatic Transfer Equipment.
15. 34 42 73 Signal Transformers.
16. 34 42 80 Operations Recorders.
17. 34 42 81 Non-Vital Processors.
18. 34 42 82 Control Panels.
19. 34 42 85 Vital Microprocessor Interlocking System.
20. 34 42 87 AVI System.

1.02 QUALITY ASSURANCE

A. Other than test equipment, all materials to be identical in quality to the components or assemblies furnished and installed under the respective Specification Section covering the item.

B. All Line Replaceable Units (LRUs) defined as the lowest level of equipment that may be replaced in the field (with the exception of fuses and resistors) to be barcoded with a unique code.

C. Factory tests to be equal to those as specified within the applicable sections of these Specifications.

1.03 SUBMITTALS

A. Two copies of the syllabus for training of the CTA's operating and Control Center personnel. This syllabus to be submitted to the CTA Signal Engineer and approved 90 days prior to the start of the first/initial cut-over, field test, modification and/or integration of the train control system.

B. Two copies of the syllabus for training of the CTA's technical maintenance and engineering personnel. This syllabus to be submitted to the CTA Signal Engineer and approved 90 days prior to the first/initial cut-over, field test, modification and/or integration of the train control system specified herein.

C. Each syllabus to include an outline of the course material, details of the textual materials, and descriptions of the visual films to be used.

D. Two draft copies each of the Contractor's proposed User Manual and Technical Maintenance Manual.

E. EQUIPMENT AND SUPPORT MATERIAL LISTS: To include Contractor’s intended material, apparatus tabulation number, Manufacturer’s reference number, part number, quantities, unit price and costs. Include the Contractor’s, estimate of the number of crates, packages, with packing lists as a submittal to be submitted to the CTA Signal Engineer for approval prior to shipment. Upon approval of the CTA Signal Engineer, the Contractor to ship the material to a location designated by the CTA Signal Engineer.

1. EQUIPMENT TABULATION: The Contractor to provide a spreadsheet listing for all equipment provided and the location of the equipment as installed on the system. A barcoding plan to also be included. A template for the specific formatting of the listing of equipment to be provided to the Contractor by CTA. The sheet to list all assets down to every Line Replacement Unit as agreed to by CTA. spreadsheet template to at minimum include the following columns with data filled out. Apparatus Tabulation Number Supplier Reference Number
2. Equipment Type
3. Manufacturer
4. Manufacturer Model Number
5. OEM Manual Name/Number
6. Serial Number
7. Barcode UPC
8. Installation Date
9. Warranty expiration date
10. Nomenclature of Equipment
11. Location of Equipment (Interlocking or Relay House name)
12. Chaining Point (Stationing) of Wayside Equipment (where applicable)
13. Track Number wayside equipment is installed on (where applicable)
14. Associated installation drawing name
15. Picture of Equipment as Installed (if applicable)
16. GPS coordinate locations
17. Supplemental Information (Frequency/Code Rate for AF Equipment, Layout information for switch machines, etc)

F. Track Circuit Tabulation: The Contractor to additionally provide a comprehensive spreadsheet listing all track circuits provided on the project. The precise template for this spreadsheet to be provided to the Contractor by CTA. The following columns to be provided at a minimum:

1. Track Circuit name
2. Track Circuit Type (Power Frequency or Audio Frequency)
3. Direction (NB or SB)
4. Maximum Allowable Cab Signal Speed
5. Train Detection Frequency
6. Train Detection Code Rate
7. Track Circuit Length
8. Receive Bond Stationing
9. Transmit Bond Stationing

G. In addition to the submittal of the supplemental list of recommended support items referenced herein, pamphlet and comprehensive product descriptions to be submitted for each item thereon that has not previously been submitted as a requirement of the technical sections of these specifications.

PART 2 - PRODUCTS

2.01 TRAINING

A. Maintenance Training

The Contractor to furnish one competent instructor, for nine working weeks (forty-five working days), to implement a maintenance training program.

1. This program to be in three parts and designed to train the CTA's signal maintainers and engineers in the operation and preventive maintenance of the new train control system equipment. The Contractor to video record each training session and provide 3 copies of each video on digital video disk to the CTA.

   a. The first part to include the following:

      i. Operation.
      Lubrication.
      Adjustment.
      Maintenance.
      Other work required to keep the new signal system in proper and continuous operation.

   b. The second part to include the following:

      i. Operation.

Adjustment.
Maintenance.
Repair.
Diagnostics.
Troubleshooting.
Programming required to maintain and perform modifications to the microprocessor and signal communication systems.

c. The third part to consist of the following:

i. Operation.
Adjustment.
Maintenance.
Repair of the audio frequency track circuits and circuit boards.

d. Each part to be for a one-week period, and to consist of a class of ten maintainers or signal engineers.

e. The three-part program to be repeated three times for a total of thirty personnel.

i. The scheduling of each three-part program will not be contiguous over a nine-week period.
Each three-part class will be scheduled separately as directed by the CTA.
The Contractor to be required to accommodate three separate trips for training.

2. All training for equipment and systems to take place in Chicago.

a. The room(s) for training will be provided by the CTA, and to also include on-site instruction.

b. This training program to be conducted no less than 30 days prior to the time that the first part of the system is scheduled to be placed in service.

c. The training program will commence upon notification to proceed from the CTA.

d. The training program to be conducted at the hours designated by the CTA, various hours/days may be required to perform the training programs

3. Training to be aided by illustrated and diagrammatic textual material furnished by the Contractor.

a. All training and maintenance material to be provided electronically on separate USB flash-drives (3 Copies) in an editable format readable by the CTA.

b. If the media required is not in Microsoft Word or PowerPoint format, the Contractor to provide two licensed copies of the media/programs for the Authorities use.

c. All training material to become the property of the CTA.

d. The Contractor to provide fifty (50) bound copies of complete operating and usage instructions, in accordance with the approved syllabus, not later than 60 days prior to the time the first part of the system is scheduled to be placed in service. These instructions to be furnished in addition to the maintenance and operation manuals specified within these Specifications.

e. The manuals to be so written that the average qualified technician is able to maintain, repair, test, modify, troubleshoot and adjust the equipment. These manuals to include, but not be limited to, the following:

i. Complete description of operation and usage.
Theory of operation.
Complete block, schematic and wiring diagrams of system and subsystems.
Diagrams showing interconnections to external equipment, including input and output connections, including cabinet equipment interconnections.
Complete installation, alignment, and adjustment procedures.
Diagnostic procedures to locate or isolate failed components.
Routine preventive maintenance procedures.
Typical programming procedures to add and delete track circuits, signals and switches from the microprocessor.
Complete replacement parts list identifying OEM parts and numbers.
Recommended sources for procurement of failed components.

B. Rail Operations and Control Center Training

C. The Contractor to furnish one competent instructor, for ten working days, to train the CTA Rail Instruction department on the implementation of an operational training program. These instructors would in turn train CTA Rail Operations and Control Center personnel.

1. One class of up to ten CTA instructors will be trained.

a. The Rail Instruction class and the development of in-house training materials to be completed prior to the commissioning of the first interlocking.

b. A video record of the Rail Instruction class to be provided.

c. CTA will provide a classroom space. All training aides (recorders, projectors, flip charts, etc.) to be provided by the Contractor.

2. Content to include overview of the train control system, typical signal system normal and abnormal operational procedures, traditional LCP features, “soft panel” features, and CTC features.
3. Review of all facilities upgrades including location of all control towers.
4. Review of new track configuration at Clark Junction, Kenmore, Montrose, Berwyn/Argyle Middle Track and Thorndale Interlockings.
5. Scope to include development of training manuals, outlines for modified/new SOP’s and development of all class-room materials.
6. The Contractor’s instructor to allow four additional weeks to work with CTA Rail Instruction to develop class room materials for use during CTA in-house training.
7. Rail Ops training deliverables:

a. Three soft copies of all training materials to be provided on disk.
b. Ten hard copies of all Instructor training materials
c. One-hundred hard copies of in-house training materials
d. DVD recording of initial Rail Instructor training

2.02 COORDINATION OF TRAINING PROGRAMS

A. The training programs to be given at such time or times, as designated by the CTA, which will not interfere with the normal operation of the CTA's system or with the construction schedule.

B. All of the Contractor’s training obligations must be met prior to project completion.

C. Final payment will not be met until all of the Contractor’s technical support obligations are met.

2.03 TECHNICAL AND MAINTENANCE MANUALS

A. Twenty-five manuals of types shown to be furnished to the CTA.

1. Solid State Equipment:

a. Complete service manuals to be provided which include the basic theory, logic, logic diagrams, circuit diagrams, detailed schematics and a complete parts list. These manuals to also include installation instructions, recommended maintenance procedures and troubleshooting guides for field and shop repairs.

2. Switch Machines:

a. Manuals describing the installation, operation, and maintenance of the power switch-and-lock movements.

3. Train Stop Layouts:

a. Manuals describing the installation, operation, and maintenance of automatic train stops.

4. Audio Frequency Track Circuits:

a. Manuals describing the operation and maintenance of the audio frequency equipment.

5. Power Frequency Track Circuits:

a. Product information and service manuals for the power frequency track circuit system furnished.

6. Relays:

a. Manuals, of relay specifications and calibration sheets for each type of relay furnished.

7. Automatic Transfer Switches:

a. Operation and maintenance manuals, including troubleshooting guides for field repairs.

8. UPS:

a. Operation and maintenance manuals.

9. Inverter System:

a. Operation and maintenance manuals.

10. DC Power Supplies:

a. Operation and maintenance manuals for each type of DC power supply provided.

11. Operations Recorders:

a. Operation and maintenance manuals, including troubleshooting guides for field repairs, for the operations recorders furnished.

12. Vital and Non-Vital Processor:

    a. Installation, operation, maintenance, troubleshooting and application manuals for the installed VP and NVP system(s) complete with troubleshooting procedures and detailed parts lists.

        i. The manuals to be written so that the average qualified technician will have the ability to maintain, repair, test and adjust the equipment.
        The manuals to include a complete description of the system operation, installation, alignment and adjustment procedures and trouble symptom charts to assist in locating malfunctions and locating failed components.
        Manuals for all software and hardware provided as part of the development system to also be furnished.

13. Control Panels:

    a. Operating manuals describing operation of the control panels and a complete schematic and parts list of all control and indicator devices.

14. Maintainers Work Station:

    a. Operating manuals describing operation of the workstation including manuals covering all software and hardware provided with the workstation.

15. Fiber Optic Network Equipment:

    a. Operation and maintenance manuals, including troubleshooting guides for field repairs, for the network equipment furnished.

16. Switch Overload/Control Module:

    a. Operation and maintenance manuals, including troubleshooting guides for field repairs, for the units furnished.

17. Automatic Vehicle Identification Equipment:

    a. Operation and maintenance manuals, including troubleshooting guides for field repairs, for all the automatic vehicle identification equipment furnished.

18. Fire Suppression Systems:

    a. Operation and maintenance and troubleshooting manuals.

19. Heating, Ventilation and Air Conditioning Systems:

a. Operation and maintenance and troubleshooting manuals.

B. Two additional copies of all manuals and technical information listed above to be provided for, and delivered to, each signal house, room or tower location that uses the equipment, to include:

1. Solid State Equipment.
2. Switch Machines (hand and power).
3. Electric Locks.
4. Signal and Route Selector Layouts.
5. Train Stop Layouts.
6. Audio Frequency Track Circuits.
7. Power Frequency Track Circuits.
8. Relays.
9. Vital and Non-Vital Microprocessors.
10. Automatic Transfer Switches.
11. Uninterruptable Power Supplies.
12. Inverter Systems.
13. DC Power Supplies.
14. Event Recorders.
15. Control Panels.
16. Maintainers Work Stations.
17. Operations Recorder.
18. Fiber Optic Network Equipment.
19. Switch Overload/Control Modules.
20. Automatic Vehicle Identification Equipment.
21. Fire Suppression Systems.
22. Heating, Ventilating and Air Conditioning Systems.

C. Manuals listed above included in houses, rooms or towers to be indexed and placed in a logical order bound in one or more three-ring binders and to be included in the relay house, room or tower at the time of delivery.

D. One electronic version of all manuals and technical information to be furnished to the CTA on a USB flash-drive.

2.04 GROUP 1 EQUIPMENT

A. The following identifies the names of the separate locations that to be used for purposes of determining material and equipment to be furnished under this Section:

1. Clark Junction
2. Kenmore Interlocking

3. Addison Audio House
4. Montrose Interlocking
5. Argyle Interlocking
6. Berwyn Interlocking
7. Berwyn Audio House
8. Thorndale Interlocking
9. Loyola Audio House
10. Jarvis Relay Room
11. Intermediate Audio Houses between Thorndale and Jarvis

B. The following items of equipment to be furnished not later than thirty days prior to the Contractor's field-testing of the train control system:

1. One for every twenty-five manual trip release key-by units, including all mounting brackets and hardware.
2. One for every twenty-five route selector units, including all mounting brackets and hardware.
3. Two pairs of each length and type of electric switch and trip heater elements.
4. One for every eight heat contactors provided.
5. One of each type ground detector provided per location.
6. One of each type switch overload module and switch control module provided per location.
7. One of each type of special purpose relay provided per location:

    a. Switch Overload.
    b. Switch Control.
    c. Polar.
    d. Vane.
    e. Audio Track Circuit.
    f. Where multiple relays of the same type are used at a single location, one relay for every twenty-five, or fraction thereof, to be furnished for each location.

8. A calculated quantity of each type of biased-neutral relay, non-vital relay, timer, and timer unit/module for each location. The calculation of Group 1 equipment to be on the quantity of each new type used at each location:

QUANTITY OF EACH TYPE RELAY USED AT THE LOCATION	GROUP 1 EQUIPMENT TO BE PROVIDED FOR THE LOCATION

1 to 25	1 of each type
26or more	4% of each type used, rounded to the nearest whole number

9. A minimum of one each of each other type of relay, other than those listed as "special purpose" above, to be furnished for each location.
10. Eight of each type and size fuse provided, including pc-board fuses per location.
11. Twenty lamp bulbs/LED's of each type for each control panel and indication panel.
12. Ten main LED arrays of each type for all aspects except red and ten side-light arrays of each type for the wayside signals (including worker ahead signals).
13. Twenty main LED arrays of each type for red aspects and twenty side-light arrays of each type for the wayside signals (including worker ahead signals).
14. One of each type of power unit provided per location:

    a. Rectifier.
    b. Power supply.
    c. Power supply module.
    d. Uninterruptible power supply.
    e. Battery charger.
    f. DC-DC converter.
    g. Units in items a through f above with different manufacturer, current ratings or voltage ratings to be considered different types.

15. Non-Vital Processors:

    a. One of each type of non-vital component provided per location:

        i. Card file.
        Backplane.
        Chassis.
        Each type connection cables utilized.

    b. One of each CPU board or module used per location.
    c. Three of each type of non-vital:

        i. Input board or module, to be furnished for each location.
        Output board or module, to be furnished for each location.

    d. One of each type of any other board or module provided for each location.

e. One memory modules of each type used per location.

16. Vital Processors:

a. Four vital card files with cables to be furnished for the project.
b. Three of each type of vital:

i. Input board or module, to be furnished for each location.
Output board or module, to be furnished for each location.

c. Two CPU board or module used per location.
d. One of each type of any other type of board or module provided per location.
e. One memory module of each type per location.

17. Twenty-five of each type of EPROM, Flash Prom, and any other programmable application or configuration device used on the project.
18. One track and signal transformer of each type provided per location. Exterior signal power transformers for utility supply to the houses are not included within this grouping.
19. One for every ten or portion thereof of each type impedance bond provided.
20. One for every ten sets of each type of impedance bond cable connectors.
21. One for every ten of each type impedance bond mounting hardware.
22. Audio Frequency Track and Cab Signal Equipment:

a. One card file/module/chassis of each type to be provided for each new location where utilized. Card files/modules/chassis to be furnished complete with backplane connectors, busses and plug connectors.
b. For all frequency-dependent track circuit transmitter and receiver boards, furnish two boards of each type for each frequency for each location. For all other boards, provide two boards of each type for each location.
c. For all frequency-dependent cab signal boards, furnish two boards of each type for each location.
d. For output transistor modules that are integral to the AF card files, furnish four modules of each type for each location. Where transistors are socket mounted or non-integral, furnish four matched sets of each type of power transistor for each location.
e. One RP repeater module for each ten, or fraction thereof, repeater modules provided of the same type for each location.
f. One loop-coupling transformer for each twenty, or fraction thereof, loop-coupling transformers provided of the same type for each location.

g. Two of each type extender board for troubleshooting and adjustment per location.

23. Two of each type train stop assembly and layout complete for tie/ballast, tie/aerial or direct fixation installation.
24. Two of each configuration of route selector assembly, including mast and junction box.
25. One for every ten of each type dual control power/hand throw type switch machine assembly.
26. One for every ten of each type dual control power/hand crank type switch machine assembly.
27. Two of each type dual control hydraulic throw type switch machine, complete assembly with controller, power unit and connecting rods.
28. One for every ten of each type switch layout complete (including all point detector, throw, and lock rods, baskets, all insulation, all attachment hardware including nuts, bolts, washers, etc.)
29. One complete set of switch adjustment tools per location.
30. Four complete sets of track shunts for adjusting, testing and calibrating track circuits.
31. Three insulated joint tester Ultra-Tech Enterprises P/N 17373-00.
32. Three insulated fault locators Ultra-Tech Enterprises P/N 17800-00.
33. Two clamp on ground testers Ultra-Tech Enterprises P/N 17549-00.
34. Fifty relay stab removal tools.
35. One of each type e-post wrench or similar tool required to test/de-energize the various relays per location.
36. Two pin extractor tools for each type of plug coupler used per location.
37. Local Control and Indication Panels material:

    a. One of each type of auxiliary switch lever used on local control panels per location.
    b. One of each type of switch heater control switch used on local control panels per location.
    c. Two of each type of entrance-exit push/pull button used on local control panels per location.
    d. Two of each type of emergency release push/pull button used on local control panels per location.
    e. Two of each type of push-only button used on local control panels per location.

38. One (1) inverter package of each size and type.

39. Two (2) HVAC lead/lag control modules complete with Ethernet boards, thermostats and humidistats.
40. Two (2) maintainer workstations complete with monitor, mouse, keyboard and other associated equipment.
41. One (1) preconfigured signal network server complete duplicate of the final product provided under the contract including all accessories.
42. One Hewlett Packard Model Laser Jet MFP M680z color laser jet printer HP part number CZ250A. Printer to be delivered to Signal engineering at 567 W. Lake St office and to include 2 additional cartridges of each color Cyan 653A, Yellow 653A, Magenta 653A and High Yield Black 653X, Printer and cartridges to be delivered to Signal engineering 9th floor 567 W. Lake St.
43. Two (2) of each type of light fixture and 4 of each type driver for each type of switch point lights (tunnel and trackside).
44. Ten (10) of each type/size interior LED light fixture.
45. Two (2) of each type exterior LED light fixture (switch point lights and signals not included)
46. A complete applications development package, including hardware, software and training to be provided for programming each type of microprocessor based equipment provided under this contract.

    a. Including but not limited to any:

        i. Vital processors.
        Non-vital processors.
        Supervisory control and/or indication systems.
        Event recorder systems.
        Code line and remote control systems.
        DTS systems, fiber optic transmission systems.
        Maintainer work station systems.

    b. The applications package to:

        i. Include all programs necessary to create or modify display screens.
        Be provided on a Contractor provided Pentium based PC of the latest technology with Windows capabilities.

    c. The Application package for modifying the interlocking logic circuitry to not require specialized knowledge of computers.

        i. The Engineering User to only require knowledge of interlocking design and the Boolean equivalents of circuits to configure or re configure an interlocking.

    d. Training to be furnished on how to create, modify and update all software, displays and programs provided.

47. Twelve complete AVI antenna and reader assemblies with all hardware/cables enclosures necessary to install them from the track to the relay house rack.
48. Two complete AVI control and indication modules or assemblies complete with all cables and hardware to connect to trackside readers.
49. Four (4) complete portable rugged AVI Tag Reader/Programmers with Lifetime CTA program license files. Rugged programmer/Readers to be Transcore E1R Encompass 1 Rugged tablet reader. Reader/Programmer to come with handstrap, 2 rechargeable battery packs, battery charger, stylus and AC power adapter or approved equivalent.
50. Twenty Four (24) programmable AVI tags Transcore AT5413 Hardened Rail Tag or approved equivalent.
51. Twelve (12) Dynamic AVI tags equivalent to Transcore AT5704 or approved equivalent
52. Twelve (12) RS485 to RS422 Heavy duty converters Black Box ICD107A.
53. For each of any other type of electronic board or module provided at each location that is not listed above, two replacement boards or modules to be furnished for each location.
54. A board / module tester to be provided for the supervisory control, signal communications and microprocessor based equipment provided for this Contract.

    a. The tester to be complete with all necessary component level schematics, documentation and necessary equipment, power supplies and devices to test and repair boards / modules and card files used in the systems to OEM standards.
    b. The tester to exercise and verify the integrity of individual inputs, outputs, serial communications channels, communications, addressing, and memory and microprocessor functionality.
    c. Disconnect switches to also be provided to energize the equipment and to connect the various units under test to the test instruments and power supply.
    d. Indicator lights to be provided repeating the operating position of the test switches and output statuses.
    e. A full complement of test leads, power leads, etc., of sufficient length to reach the equipment being tested to also be provided. Retractable reels, if necessary, to be provided for these leads.
    f. Utilizing a combination of documentation, test equipment and software the system to perform tests which will accurately verify the function of every card / board / module utilized and provide an accept or reject status of the cards / boards /modules tested.

g. The test set to have manual and automatic modes.

i. Under the manual mode the technician to step through testing each input one at a time.
Under the automatic mode, the unit to automatically exercise each input and output without additional technician intervention, once the technician initiates the test.

h. The unit to include two or three position test switches for each input and test light indications for each output.

i. The unit to include a means of dynamically testing serial communications for each communications channel, with a provision to connect an external data communications monitor.

j. A program test system to also be provided to verify the integrity of the logic memory modules. This to provide diagnostic information on the program as it runs, and to be capable of functioning both on and off line. The test devices to be self-contained and portable.

k. An EPROM test reader and Flash Prom test reader to be provided to verify the integrity of programmed chips.

l. Ten complete service manuals with detailed instructions on the use of the test equipment to be provided.

55. The Contractor to provide a cab signal / audio track circuit test rack complete with all necessary component level schematics, documentation, interconnecting cables devices and equipment to test and repair all boards, modules, synchronous coders, line drivers, and card files used in the train detection and cab signal transmission system. Test fixtures, power supplies, loading coils and wire to simulate 1000’ of rail, component level schematics and documentation necessary to calibrate, repair, and test receive only points, bonds, tuning units, and loop drivers utilized under this contract to also be provided.

a. Disconnect switches to be provided to energize the equipment and to connect the various units under test to the test instruments and power supplies. All interconnecting cabling to be provided to connect the modules and chassis and to allow combinations of modules, bonds, loop drivers and receive points to be tested.

b. Indicator lights, repeating the operating position of the switches to also be provided.

c. A full complement of test leads, power leads, etc., of sufficient length to reach the equipment being tested to also be provided. Retractable reels, if necessary, to be provided for these leads.

56. Card files to be provided at each location to house and store the GROUP 1 EQUIPMENT boards when they are not in use. The card files to be rack mounted, and the slots of them to be labeled to identify each board.
57. Rugged and portable carrying cases with hinged and latched covers and with a handle on top to be provided to house and protect each set of replacement boards and memory devices.

    a. Guides to be fitted to the interior of these cases to hold each board and prevent contact between the components of any two boards.
    b. The inside of each case to be fitted with a one-inch thick foam pad (closed cell neoprene) to protect the boards from impact during transit and storage.
    c. The maximum weight of any case with a full complement of boards installed to be twenty-five pounds. If any case exceeds the maximum weight, additional cases to be provided.

58. A minimum of two duplicate socketed PROMs/EPROMs/FLASH PROMs/signature chips of each type per each location to be furnished. Where more than eight duplicate chips exist at a location, a minimum of 25 percent spare of the total number for that location to be furnished. Four fiber optic transceiver/modems, including associated power supplies and RJ45/FO patch cables, of each type provided.
59. Four of each type Ethernet switches, including their associated power supplies and RJ45 cables, of each type provided.
60. Four of each type communications routers, patch panels, including their associated power supplies and RJ45 cables, of each type provided.
61. Four of each type fiber optic modems, media converters data switches etc, including their associated power supplies and RJ45/FO cables, of each type provided.
62. Two of each type LED switch point light fixture including remote driver modules and drivers.
63. The Contractor to provide to the CTA Signal Engineering 567 W. Lake St two (2) Tektronix THS3024-TK oscilloscopes with travel kits along with (2) additional batteries, battery chargers and AC power adapters, oscilloscopes to be delivered to Signal engineering 567 W. Lake St.
64. The Contractor to provide a minimum of two (2) additional full software licenses for all required proprietary software. This to be in addition to the software licenses provided for each of the engineering laptops, Maintenance Workstations, and otherwise as necessary.

65. The Contractor to provide to the CTA one (1) Yokogawa Model number DL850E-D-HE/M2/HD1/C1/G2/G3/P4 Scope Corder with the following modules and accessories: Two (2) 720211 High Speed/ High Voltage 100 MS/s Modules, two (2) 701250 High Speed/ High Voltage 10 MS/s Modules. Two (2) 701947 100:1 probes, six (6) 700929 10:1 probes, two (2) 701948 plug on clips, two (2) 701903 2M safety BNC cables, two (2) 758924 safety BNC to banana adapters, two (2) 758922, 701954 and 758929 Alligator clip adapter sets, two (2) B9852MM and B9852MN, one (1) 701930 Current Probe and one (1) Licensed copy of 701992 Xviewer Upgrade Version software. All above equipment to be delivered to Signal Engineering 567 W. Lake st.
66. The Contractor to provide to the CTA one (1) Dewetron DEWE2-A4 portable measurement system with the following accessories/upgrades: one (1) option DW2-PS-DC-BUFFER internal battery, one(1) option SSD-120-480 flash disk upgrade to 480 GB, one (1) DW2-UPS-150-DC External UPS and multi Battery Charger. two (2) additional BAT-95WH Lithium ion Batteries, one (1) BAT-CHARGER-1 desktop battery charger, one (1) TRION-1620-ACC-6-BNC module, one (1) TRION-2402-V-8-B module, two (2) TRION-2402-V-4-B modules one (1) TRION-TIMING module, one (1) TRION – VGPS200C module with optional display and hard carrying case, one (1) GPS Antenna GPS-ANT-2, one (1) licensed OXYGEN software with Power Option, one (1) XSENSE-MTi-G-710 Motion Tracker with GPS, one (1) PLUG-IN-XSENSE plug in module for the Motion Tracker, one (1) DEWESOFT DS-7 Software Licence, and (1) DEWE2-CC Carrying Case, All above equipment to be delivered to Signal Engineering 567 W. Lake st.
67. The Contractor to provide the CTA with six (6) wireless industrial barcode scanners capable of scanning the bar-coded equipment provided on the project. Scanners provided to be Symbol/Motorola model LS3578-ER-USB kit including charging and communications cradle, USB cable, power supply and line cord. six (6) additional lithium ion batteries for the above scanner to be included Symbol part number BTRY-LS341AB00-00.
68. The Contractor to provide Six (6) engineering laptops with all software development software and complete Microsoft Office Suite Professional installed. The laptops to come with copies and licenses of all required software for all equipment provided on the project. Laptops to also come with all required connectors for communicating and programming all provided equipment. Laptops provided to be Dell Lattitude 14 Rugged Extreme model with the following configuration: Intel Core i7 3.40 GHz 4M cache, Windows 10 Pro 64-Bit English, Microsoft Office Professional 2016 or latest version, 16GB 2133 MHz DDR4 Memory, 512 GB Mobility Solid State Hard Drive, AMD Radeon R7 M360 Video Card, Intel Dual Band wireless-AC 8260 Wi-Fi +BT 4.2 wireless Card, 9 Cell 97 Watt hour Lithium Ion Battery, 90 watt A/C adapter (3 pin), Dell

external USB Slim DVD+/- RW Optical Drive, Dell Soft Laptop carrying case Sealed internal backlit RGB keyboard, Cyberlink Media suite with essentials, 3 year Warranty transferable to CTA. All above equipment to be delivered to Signal Engineering 567 W. Lake st.

69. The Contractor to provide the CTA with one (1) Ultra-Tech Enterprises contact resistance measurement system UTE part # 15967-00 consisting of one (1) Multiple relay test rack assembly module UTE part # 16575-00 with B1 type # 16601-01, B2 type # 16603-01, PN-150 type # 16605-01, and PN-250 type # 16607-01 test bases and one (1) Contact resistance measurement unit (CRMU) UTE part # 16575-00 and connector cable assembly.
70. The Contractor to provide the CTA with one (1) Ultra-Tech Enterprises DC Relay Test System P/N 40086-00 for PN-150 and B1 relays.
71. The Contractor to provide the CTA with one (1) Hewlett Packard Proliant ML-110 Gen9 Server with 16 MB upgrade 1 TB hard drive,550W power supply Intel XEON E5-1620 V4 processor and windows server 2016 HP number 840667-S01 The server to include one (1) HP 24" E242 monitor , USB Keyboard and mouse, server to be utilized for the relay test records.
72. For purposes of determining material furnished under this section, physically identical programmable boards or modules containing different user programmable/configurable chips to be considered as being the same type of board.

2.05 GROUP 2 SUPPORT MATERIAL

A. The Contractor to submit his GROUP 2 SUPPORT MATERIAL list of suggested technical support material, complete with unit prices, within 120 days after notice-to-proceed. The list to include the following:

   a. Contractor's apparatus tabulation number.
   b. Manufacturer's reference number.
   c. Recommended quantities.
   d. Costs and failure probabilities.

B. The CTA will provide the modified and approved GROUP-2 SUPPORT MATERIAL list to the Contractor within 60 days of receipt of the Contractor's recommended list.

C. Upon approval of the CTA, the Contractor to ship the GROUP 2 SUPPORT MATERIAL to a site designated by the CTA. Material to not be delivered directly to the project site.

D. The Contractor to furnish price lists and actual purchase invoices to substantiate unit prices, for all GROUP 2 SUPPORT MATERIALS furnished.

E. If there is a difference in the cost between the bid-amount and the total approved value of the GROUP 2 SUPPORT MATERIAL then it to be reconciled with a CONTRACT CHANGE ORDER.

2.06 GROUP 3 SUPPORT MATERIAL

A. A supplemental list, designated as GROUP 3 SUPPORT MATERIALS, for apparatus over and above that designated for GROUP 2. The GROUP 3 list will be evaluated by the CTA for separate, or change order procurement.

B. The GROUP 3 list to be furnished not less than 60 days prior to the time that the first part of the system is scheduled to be placed in service.

2.07 FIELD SUPPORT

A. The primary signal supplier to furnish a local technical representative a period of one year starting at substantial completion. Office space will be provided by CTA and the tech rep will be stationed on CTA property during regular business hours. Off hour availability will be required for support of off-hour software and hardware changes.

B. This individual will be the primary contact for warranty issues. Other assignments could include clean-up of Final Acceptance items and assisting with maintenance training.

C. The tech rep to be proficient in the programming of the vital and non-vital interlocking processors, programming and adjustment of the signal communications system, adjustment of AF track circuits and of all field appliances.

PART 3 - EXECUTION

3.01 DELIVERY, STORAGE, AND HANDLING

A. All equipment provided under this Section to be packaged to preclude deterioration of the product.

B. The number of crates and packages, and packing lists to be submitted to the CTA for approval prior to shipment.

C. The Contractor to ship all approved support material equipment to the area designated by the CTA, not less than 60 days prior to the time that the first part of the system is scheduled to be placed in service.

D. Any items having a limited shelf life to be clearly identified on the storage container with the expiration date.

E. The Contractor to obtain a signed receipt for all materials, and promptly post such receipts as an issue on the project web site.

F. With the exception of storage card files, material to not be delivered directly to the field locations identified in this section.

4.01 MEASUREMENT

A. The work of TECHNICAL SUPPORT shall not be measured for payment.

4.02 PAYMENT

B. No separate payment shall be made for the work covered in this section. Payment for the Work of TECHNICAL SUPPORT shall be included in the contract lump sum price as shown in the Schedule of Prices for SIGNAL AND TRAIN CONTROL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

C. Signal and Train Control Work: 344200

END OF SECTION

SECTION 34 42 91
SIGNAL SYSTEM TESTS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. The work to be done under this Section consists of the tests and inspections that will be performed to demonstrate that signal components and designs are in compliance with the specifications and that the wayside train control system is functionally and safely integrated into the carborne ATP system, the communications backbone system, the Control Center RSMS system and the traction power negative return system including, but not limited to:

   a. Systems.
   b. Subsystems.
   c. Assemblies.
   d. Subassemblies.
   e. Components supplied under this Contract.

2. Tests and inspections will be made both during the progress of this Contract and after completing the installation of equipment and will consist of, but not be limited to:

   a. Factory tests.
   b. Circuit breakdown tests.
   c. Wiring verification tests.
   d. Continuity tests.
   e. Resistance tests.
   f. Voltage and current tests.
   g. Time tests.
   h. Operating tests.
   i. Simulation tests.
   j. Other electrical and mechanical tests and inspections.

3. The work will include the costs of the Contractor's personnel and any special equipment and assistance required to conduct all tests and complete the required documentation.
4. In the event that the system does not meet the Specification requirements, necessary corrections will be made and any and all tests or retests to prove compliance will be included in the work, without any additional cost to this

Contract. The CTA will be made aware of any failures at the time of their occurrence, along with preliminary measures to correct them, and the final measures presented in writing through the RFI process.

5. The work will include all necessary test purpose disconnecting and reconnecting.
6. Test work specified elsewhere in these Specifications will be construed as related to and inclusive with the testing described herein.

B. Standards and Regulations:

1. Standards – American Railway Engineering and Maintenance-of-Way Association, Signal Manual, Part 2.4.1 "Instructions for Inspection and Test of Signal Installations before Placing in Service."
2. Regulations Federal Railroad Administration, Rules, Standards and Instructions for Railroad Signal Systems, Part 236.

1.02 SUBMITTALS:

A. Submit the following for approval by the CTA:

1. Within 90 days after receipt of Notice to Proceed, the following will be submitted:

   a. An outline of the tests to be performed on each type of component or unit, together with sample forms of test record forms and cards as hereinafter specified.
   b. The numbers of each type of component or unit to be tested to demonstrate the adequacy of design and quality control.
   c. A line diagram showing the grouping and sequencing of system and subsystem tests showing both factory and field tests.
   d. Any additional tests required by the Contractor to ensure the safe operation of the system will be submitted.

2. At least 60 days prior to the scheduled performance of each test, a detailed test procedure, for tests as described herein, will be submitted to the CTA for approval.

   a. Discrepancy forms will accompany each test.

      i. All discrepancies and corrective actions will be listed on these forms.
      ii. Tests will not be considered complete until all discrepancies, if any, have been resolved with the CTA approval.

3. The completed results of each test as herein specified will be recorded and the test result documentation will be furnished within 10 days of completion of the test. Certified test results will also be furnished for tests performed by any subcontractors when such tests are required within this Specification.
4. All test reports will be checked and approved by the Contractor prior to submittal.
5. Test reports will document the calibration date of each instrument used during the test.

    a. The calibration of each instrument will be certified by a recognized testing facility.
    b. Recertification will be conducted every 90 days or as stated by the manufacturer's recommended calibration period. Out of date instruments will be considered non-certified.
    c. Tests conducted with non-certified instruments will be rejected.

6. Upon completion of all tests specified herein, the Contractor will submit a letter signed by an authorized representative, certifying that all tests have been performed.

1.03 QUALITY ASSURANCE

A. All test procedures and inspection procedures will be subject to the approval of the CTA and will comply with all FRA and AREMA rules and regulations, including AREMA Manual Part 2.4.1 "Inspection and Test of Signal Installation before Placing in Service."

B. Test equipment of the proper type, capacity, range and accuracy will be supplied by the Contractor to perform the required tests and inspections. This equipment will be in good working order and properly calibrated at the time the tests or inspections are conducted.

C. Each component and unit of the wayside signal and train control system will have an inspection performed at its point of manufacture and evidence of this inspection and acceptability will be indicated on the item where practicable.

D. CTA Factory Inspection

1. The CTA reserves the right to witness any or all tests and inspections in the Contractor's plants or other manufacturing facilities.

    a. The CTA will be advised a minimum of ten weeks in advance of each factory test.
    b. When tests are to be conducted continuously as in a production line routine, the CTA will be advised six weeks in advance of the start of such

tests and such notice will indicate the duration period in which such tests will be conducted.

2. Travel will be required by the CTA to the Contractor's factory as follows:

   a. First trip for a design conference/prototype inspection.
   b. Following trips to witness factory/operational test for each location.

3. The following conditions must be satisfied before factory testing can be scheduled:

   a. All signal circuits and programs will be approved by the CTA.
   b. The circuitry, including all panels, will be wired so that operation of all house/room equipment can be observed during simulation tests.

4. The number of trips will not be limited.

   a. Should problems develop, or if the manufacturer's scheduling does not permit completion of tests within one visit, additional trips may be necessary to complete the objectives of this Contract.
   b. When technical information is desired, it may be such that the information can be brought to the CTA representatives instead of the CTA representatives traveling to the factory. In such case the Contractor will have the option of bringing qualified personnel to the Chicago area to accomplish the needed solution in lieu of providing for travel for the CTA.

E. All approved system and subsystem tests to demonstrate that the installation meets these Specifications and design requirements will be completed prior to any operational testing of systems or subsystems.

F. The CTA will have the right to witness any or all field tests conducted.

1. The CTA will be notified in writing at least seven days prior to each field test.
2. No part of the signal system will be placed in service without an authorized representative of the CTA being present and witnessing the in service tests.

G. The work will include all tests required to ensure the proper and safe operation of all systems and subsystems and to prove the adequacy and acceptability of the total installation specified herein.

H. The tests to be performed will cause each system and subsystem to be sequenced through its required operations, including the imposition of simulated conditions to prove that the installation complies with all specified fail safe requirements.

PART 2 - PRODUCTS

2.01 SITE TEST EQUIPMENT AND MATERIALS

A. All test instruments and equipment necessary to conduct the tests specified herein will be available, ready-for-use not less than one week in advance of test need.

B. Ready for use will mean:

1. Properly matched for test parameters.
2. Properly calibrated.
3. Sufficiently supplied with:

    a. Leads.
    b. Probes.
    c. Adapters.
    d. Stands etc. necessary to conduct the particular test in a completely professional manner.

C. All temporary or interim test related equipment will be furnished and available including, but not limited to:

1. Materials.
2. Special tools.
3. Connections.
4. Jumpers etc.

PART 3 - EXECUTION

3.01 FACTORY TEST PROCEDURES

A. Confirmation will be provided by the Contractor that all factory tests have been performed.

B. Factory tests required under this Contract are those of:

1. Systems.
2. Subsystems.
3. Assemblies.
4. Subassemblies.
5. Components.

C. The above tests will verify design and name plate ratings and adequate and proper performance.

D. When test results are not recorded on a test data plate affixed to the equipment or unit, certified test reports will be furnished for each item at the time of delivery in a form and format suitable for regular office file record keeping.

E. Each component and unit will be inspected at its point of manufacture and evidence of this inspection and acceptability will be indicated on the item where practicable.

F. All systems, subsystems, and equipment will be 100 percent inspected and tested.

G. All components, other than those related to fail safe circuits, may be tested on a sampling basis. An approved number of randomly selected components or units from the manufacturing process will be tested to ensure the adequacy and acceptability of all components and units produced.

3.02 FACTORY TESTS AND INSPECTIONS

A. Relay Houses, Relay Rooms, and Relay Cases

1. Each relay house and relay case will be wired complete at the point of assembly, with all equipment installed.
2. Each relay room relay house and instrument rack will be wired complete at the point of assembly, and interconnected with all equipment installed.
3. An operational and wiring verification test will be made in accordance with the approved circuit plans.
4. Functions external to the housing will be simulated using test panels where required.

B. Vital Relay Tests

1. All DC vital relays will be factory tested and inspected in accordance with AREMA Signal Manual Part 6.4.1.

C. Microprocessor Tests

1. These tests will be performed at the factory by the Contractor using a test panel to simulate all field connections.
2. The test panel will consist of independent indicator lights for each system output and separate two-pole switches for each input.

    a. Indicator lights will determine polarity of biased inputs.
    b. Test switches for switch repeater inputs will also establish input polarity.

3. The test panel will interface with the microprocessor system via the main terminal board racks and the control panel.

4. The system will be configured to allow full functional testing using the test panel, control panel and the microprocessor system operating.
5. Complete breakdown and operational testing will also be performed at each location when the system is delivered and connected to the field equipment; this will take place prior to placing the system in service.
6. Detailed breakdown and test procedures will be provided to the CTA and approved prior to testing.
7. The CTA will verify the operational check at the factory and in the field as specified within these Specifications.

D. Energy Distribution Tests

1. The tests will include but not be limited to the following:

    a. All fuses will be removed.
    b. Verify that circuit breaker size compares to that shown on the approved circuit plans.
    c. All energy distribution will be checked using resistance test instrument acceptable to the CTA, to verify agreement with the approved plans.
    d. Verify wire gauge with that called for on the approved circuit drawings. All discrepancies in wire sizes will be replaced with the proper size wire.
    e. Each energy bus will be tested to all energy buses to ensure that no crosses exist.

2. Any discrepancies found will be corrected.

E. Wiring Verification Test

1. All circuitry will be checked for accuracy against the approved circuit drawings. Tests may be done with energy on or off and will verify the following:

    a. Point to Point wiring.
    b. During wire verification test, a wire count on each terminal, relay contact, etc. will be taken to ensure that only the number of wires called for on the approved circuit plans is present at each terminal, relay contact, etc. Verify tags and nomenclature where applicable.
    c. Verify that all components, relays, resistors, etc. are the same as called for on the approved circuit drawings and located in proper positions.

2. Any discrepancies found will be corrected.

F. Vital Circuit Tests

1. Tests will be conducted with energy on during simulation testing.
2. All vital circuits will be tested to ensure that the opening of each contact in a control circuit cuts off the control current under the conditions shown on the approved plans following through all multiple circuits and cut-arounds.
3. When a circuit is broken by a relay contact twice or when it is broken by some other relay contact, whose coil circuit is opened by opening the relay, the wires in the circuit will be disconnected in addition to opening the relay.
4. Any discrepancies found will be corrected.

G. Interlocking Tests

1. After conducting the vital circuit tests, the Contractor will simulate all operating conditions to ensure that each circuit function is in accordance with the specifications. Functions tested will include, but not be limited to, the following:

    a. Approach and time locking.
    b. Route locking.
    c. Detector locking.
    d. Traffic locking.
    e. Verification of time release settings.
    f. Route setting and cancellation in both the automatic and manual modes of operation.
    g. Proper polarity of energy that will interconnect with the existing and new circuitry outside the housing, room, or case tested.

2. Adjustments and corrections of defects in the wiring will be made as necessary to obtain proper operation.
3. All design changes found necessary to obtain proper operation will be submitted to the CTA for approval.

H. Instrument Racks

1. The complement of instrument racks and equipment will be wired at the point of assembly, with all equipment installed.
2. The racks will be interconnected in accordance with the approved drawings.
3. All functions of the system will be simulated to determine that each function of the system operates as required.
4. Adjustments and correction of defects in the rack wiring will be made as necessary to obtain proper operation.
5. All design changes found necessary to obtain proper operation will be submitted to the CTA for approval.

I. Control Panels

1. All operating functions and indications of the control panels required by this Con-tract will be tested to determine that each function will perform as required.
2. This test will be performed in conjunction with the associated instrument rack and microprocessor system tests as specified herein.
3. Adjustments and correction of defects in the control panel and equipment wiring that are necessary to obtain proper operation will be made.

J. Supervisory Control System Factory Test

1. Prior to initial shipment of the Supervisory Control System, a system functional test will be conducted.
2. This test will include the assembly and inter-connection of all supervisory control apparatus, data transmission equipment, and field apparatus for each of the field station control points to be controlled under this Contract.
3. Where simulation, or test fixture equipment, is required to perform this factory test, such equipment will be provided by the Contractor at no additional cost to the CTA.
4. Functions to be tested will include all control manipulations and indications between central control and all field locations to verify the supervisory control and data transmission system operation.

    a. Simulated data streams will be injected into the system at all input point at a rate twice the calculated normal through put.

5. Test will also include all control manipulations and indications corresponding to the system design.
6. No shipment will be accepted at the site if the supervisory control factory test results have not been approved to the CTA.

K. Operation Recorder

1. Verification of indication to the proper input location on the recorder and all subsystem interfaces into the recorder..

L. Other Factory Tests

1. Factory tests and inspections of other components, products and subsystems may be found in the respective technical sections of these Specifications.

3.03 FIELD TEST PROCEDURES

A. The field tests performed will cause each installed system and subsystem to be sequenced through its required operations, including the imposition of simulated conditions, to demonstrate that the installation complies with all specified fail safe design requirements and operational functions.

B. The quality of the installation will be demonstrated by field tests for:

1. Continuity.
2. Insulation resistance.
3. Resistance of ground connections.
4. Circuit breakdown.
5. Visual inspection.
6. Any other tests required by this Specification.

C. These above installation quality tests will be performed prior to any operational testing of systems or subsystems.

D. The Contractor's test procedures will include a narrative for each test. The narrative will at minimum include:

1. Purpose of test.
2. Pre-requisites.
3. Test equipment required to perform tests.
4. Testing method and procedure.

E. The Contractor's test procedures will consist of pre-printed data sheets or inspection sheets for each test. When completed by the field test personnel and checked for accuracy and completeness, the sheet will be submitted as the test report.

F. When tests require specific meter or test instrument readings, the pre-printed data sheet will show the allowable range of values, for each part of the test.

G. The test report will also contain:

1. A check off system for each action and a blank space adjacent to the expected value in which to record the test readings.
2. A final discrepancy sheet on which the Contractor will record discrepancies found and action taken. This documentation will be furnished to the CTA.
3. Space for the printed name and signature of the Contractors responsible employee and witnessing inspector.

H. All test reports will be dated and signed by the responsible employee of the Contractor or subcontractor on the day the test is performed.

I. The report will show the specific test instruments used on each test, with the instruments identified by name, type, serial number, and calibration due date.

J. Should an error be discovered during field testing, due to field wiring and connections that do not agree with the approved circuit plans, the Contractor may correct such errors without prior approval of the CTA. The Contractor will not, however, make any changes that affect safety of operation of the approved circuit(s), as designed, without prior written approval of the CTA.

K. The CTA will make all final determinations as to whether only a part, or the whole test, will be rerun when any specific field test does not meet the requirements specified for the test.

L. Any changes made after completion of test procedure will be retested in accordance with the applicable test procedure.

3.04 GENERAL FIELD TESTING AND INSPECTION

A. General field tests will include, but not be limited to, the following:

1. Test to ascertain removal of all negative rail connections from the signal rail for single rail track circuits, and removal of negative rail connections from both rails for AF track circuits.
2. Ground verification test.
3. Vital relay calibration inspection.
4. Inverter and commercial power operation and transfer tests.
5. Power racks, energy distribution system and failure alarm checks.
6. Breakdown test of all vital circuitry.
7. Wiring verification of all non-vital circuitry.
8. Line circuit verification between wayside relay houses/rooms.
9. Vital function tests.
10. Operating tests.
11. Dynamic and safe braking tests with a derated train.
12. All applicable tests prescribed by AREMA Signal Manual Part 2.4.1, where the AREMA inspections and tests do not conflict with the requirements of these specifications.
13. Ancillary signal house/room equipment, alarm and HVAC system tests.

3.05 SPECIFIC FIELD TESTS

A. Resistance of Ground Connections

1. All grounding connections will be tested to determine that the ground resistance is not greater than 15 ohms using the Ratio Ground Resistance test method. All ground connections will be tested.

B. Insulation Resistance Tests

1. The test procedure for testing of insulation resistance will include tests to verify the following:

    a. All wire and cable installed along the right of way and the wire and cable entering or leaving wayside relay houses, rooms, towers, and cases will be tested after installation to ensure that insulation of wires and cable and connected equipment meet the specified resistance value.

        i. A direct reading instrument, having a 0 megohm to 200 megohm scale range and a self-contained DC power supply rated 500 volts minimum to 1000 volts maximum, will be used to measure the insulation resistance.

        ii. Resistance between conductors and ground will not be less than that specified in the Federal Railroad Administration Rules, Standards, and Instructions for Railroad Signal Systems, Part 236.108.

    b. The insulation resistance of each conductor to ground and between each conductor and all other conductors in each multi conductor cable will be tested.

        i. Power sources, made grounds and connections to the rails will be disconnected from the circuits during testing.

    c. The point used as ground will be the most convenient ground available.

    d. Insulation resistance test values will be recorded on approved Insulation Resistance Record Forms and turned over to the CTA upon their acceptance of this test requirement.

C. Negative Return Rail Bonding (Single Rail Track Circuits)

1. Electrical tests of negative rail bonding will be performed only if directed by the CTA. The Contractor will exercise extreme care during these tests due to return currents that may be present in the rail.
2. When directed, electrical tests of negative return rail bonding, cross bonds and negative return traction feeder cable will be conducted and recorded as herein described using a Biddle Portable Kelvin Bridge, Catalog No. 72 439 or an equivalent test instrument with corresponding range and accuracy.
3. Tests will only be performed when no traction power energy is in the rails.
4. Approval of any power removal will be obtained from the CTA prior to testing.
5. Resistance of Welded Connections

    a. The installed resistance of each welded negative return bond will be tested to verify that it does not exceed 0.000080 ohms.

b. The Null Balance method of testing will be employed utilizing the four terminal arrangement, two potential and two current terminals.

i. The C1 and C2 current leads will be attached to the rail approximately six inches outside of welds being tested.
ii. The P1 and P2 leads will then be attached to the rail one inch from either end of the bond being tested.
iii. The meter dials will then be manipulated to achieve a balanced condition of the meter.

c. This procedure will be followed for each welded bond attached to the rail.

6. Cross Bonding

a. The installed resistance of each 1000 kcmil cross bond cable will not exceed 0.000160 ohms plus 0.000011 ohms for each foot of cable installed. The Null Balance method of testing will be employed.

7. Mechanical Tests

a. All welds will be struck with a hammer in the presence of the CTA to ensure proper bonding of the materials. Tests will be performed on the structure welds prior to repainting.

D. Vital Relays

1. All DC vital relays will be tested for pick up and drop away values. These values will be in accordance with field requirement values stated in Table I of AREMA Signal Manual Part 6.4.1.
2. These measured values will be recorded on the approved Relay Record forms and turned over to the CTA upon his acceptance of this test requirement.
3. These tests will be performed at the field locations after the housing has been set, or the room construction has been completed.

E. Inverter Operation and Signal and Commercial Power Distribution

1. Pre Power Up Verification

a. With inverter and commercial power off, fuses removed and disconnects open, testing will include but not be limited to:

i. Verify all fuses and disconnects are sized in accordance with the approved plans.
ii. Point-to-point wire verifications will be made in both the inverter and commercial/signal power racks verifying that wire run and gauge are

in agreement with the approved plans.

iii. Verify that transformers are wired in agreement with the approved plans.

iv. Verify that the inverter rack and equipment mounted upon are not within 6 feet of any potentially grounded object(s).

v. Perform ground tests on the inverter and commercial/signal power racks verifying:

Inverter rack and equipment mounted upon are isolated from earth ground.

Continuity check verifies that inverter rack and equipment mounted upon are grounded to the negative running rails as shown on the approved plans.

Signal/commercial power rack and equipment mounted upon are earth grounded and pass the minimum ground resistance requirement called for by these specifications.

b. Verify equipment and wire tags for proper type and nomenclature.

c. Verify operation of the 600VDC manual transfer switch.

2. Power On Verification

a. After completion of pre power up testing, and with power being delivered to the inverter and commercial power/signal rack, the following tests and checks will be performed.

i. Insert all fuses, close disconnects and prepare system for normal operation.

ii. Verify that Load and Line voltages are within five percent of those called for on the approved plans.

iii. Verify that commercial and signal power is being delivered in accordance with approved plans.

(a) Measure and record signal and commercial power voltages present in the signal house/room. Voltages will be within five percent of those called for on plans.

iv. Verify and record inverter indication data.

v. Manipulate transfer from inverter to commercial power and repeat 2.a, ii and iii above.

vi. Verify proper operation of 600VDC manual transfer switch.

F. Energy Distribution

1. Energy Off Tests

a. With all power to wayside relay house/room or case off, the following checks and tests will be performed. These tests will include but not be limited to:

i. All fuses will be removed.

ii. Verify that circuit breaker size compares to that of approved circuit plans.

iii. All energy distribution will be checked using resistance test instrument acceptable to the CTA, to verify agreement with the approved plans.

iv. Compare wire gauges with those called for on the approved circuit drawings.

(a) All discrepancies in wire sizes will be replaced with the proper size wire.

v. During energy distribution breakdown, a wire count on each terminal, relay contact, etc. will be taken to ensure that only the number of wires called for on the approved circuit plans is present at each terminal, relay contact, etc.

(a) Any discrepancies found will be corrected and additional wires, if found, will be removed.

vi. Tags will be verified for proper nomenclature and terminal location.

vii. Each energy bus will be tested to all other energy buses to ensure that no crosses exist.

2. Energy On Tests

a. Upon completion of the energy off tests, the following checks and tests will be performed. These tests will include but not be limited to:

i. Insert fuses for power supply feeds and verify proper size according to the approved circuit drawings.

ii. Turn on energy feeds and test operation of power transfer for proper operation.

iii. Each AC voltage input will be measured and recorded.

iv. Each power supply output voltage will be measured and recorded.

v. Verify that the proper voltage is present at all distribution points.

vi. Check circuit power failure alarms, and all other alarms that indicate to remote control points.

G. Circuit Continuity Tests

1. All wire and cable installed by the Contractor will be tested to verify the continuity of each conductor and that each conductor is connected to the proper terminal as shown on the approved drawings.

a. Where parallel circuits exist, each parallel path will be tested independently to verify the continuity of each path.

H. Vital and Non Vital Circuit Breakdown

1. All circuits will be checked for accuracy against the approved circuit drawings. Tests may be done with energy on or off and will verify, but not be limited to, the following:

a. Point to point wiring, between the field device or adjacent location, and the first relay or input/output terminal in the house (unless wiring changes have been made to the wiring internal to the house post factory test completion, in which case, the point to point test will check all elements of the circuit).
b. A wire count of all field installed wires will be made for each terminal, relay contact, etc. to ensure that only the number of wires called for on the approved circuit plans is present at each terminal, relay contact, etc.
c. Verify tags and nomenclature where applicable.
d. Verify that all components, relays, resistors, etc. are the same as called for on the approved circuit drawings and located in proper positions.

2. Any discrepancies found will be corrected.

I. Breakdown of Control Circuits

1. All circuits will be tested in their entirety for the correct operation of and response to each contact on each circuit element, such as relays and contactors.
2. Where parallel paths exist, the tests will validate each path, and circuits will be opened when required to ensure the proper test.
3. Each circuit will be tested by simulating all operating conditions to verify that the circuit operates in accordance with the Specifications and approved plans.

J. Power Frequency Track Circuit Tests

1. Each track circuit will be tested in accordance with the Contractor's approved test procedure to ensure that the 60 hertz track circuits are properly designed, installed, and adjusted, and will include tests to verify the following:

a. Each AC track circuit will be tested for defective insulated joint protection.
b. Each AC track circuit will be tested for shunting sensitivity.

i. This test will be performed by connecting an ammeter in series with the track coil of the track relay.
ii. A 0.25-Ohm shunting strap will be placed across the rails at the track transformer feed point.
iii. To be acceptable, the effective value of any current so measured will be less than 75 percent of the drop-away current of the track relay.
iv. This test will be performed after the final track circuit adjustment has been made.
v. Value of current required to pick up the track relay will be recorded.

K. Audio Frequency Track Circuits

1. Audio frequency track circuit components will be tested to ensure that the components are in compliance with the manufacturer's specifications. These tests will include but not be limited to:

    a. Code rate periods will be checked with a frequency counter and recorded.
    b. Track and train carrier frequencies will be checked and recorded for proper frequency and will be within tolerance limits.
    c. Tuning units will be checked to verify that they are tuned to proper frequency and the results will be recorded.
    d. The resistance of line wire feed to the trackside-tuning unit will be verified.
    e. The following information will be recorded and submitted to the CTA for each transmitter:

        i. Power level settings for track and train carrier frequencies.
        ii. Line voltage levels for track and train carrier frequencies.
        iii. Current readings in milli-amps for each train carrier frequency.

    f. The following information will be recorded for each receiver:

        i. The receiver input voltage value, shunted and unshunted values.
        ii. Pick up voltage of the associated receiver track relay.

2. After all the audio frequency track circuits are set up and operating, each track will be shunted to verify that only the proper track relay drops with a 0.25 ohm shunt applied to the track circuit.
3. A selected group of track circuits will be tested to determine that it is properly immune to interference. This test will be performed by first:

    a. Disabling the track circuit's transmitter without disconnecting it from the rails.
    b. Second, an oscilloscope will be connected to the receiver's detector at a point before the signal is digitalized or limited. The oscilloscope waveform will be observed for:

        i. Harmonic interference from adjacent transmitters.
        ii. Traction power noise.
        iii. Noise from moving trains, and for other undesirable sources of noise.

    c. To be acceptable, the effective voltage level of any signal so observed will be less than 75 percent of the minimum voltage level, at that point, required to hold the track relay in an operated state. This check will be made with the receiver set to maximum sensitivity.

d. At a minimum, one track circuit for each combination of frequencies and modulation rates will be tested.

4. A select group of track circuits will be tested to determine that speed commands cannot be received by a train behind the train for which they are intended. This test will be performed by:

a. Causing the transmitter to transmit a speed command.
b. Placing three 0.25-Ohm shunting straps across the rails, ten feet from the transmitter bond.
c. Connecting an oscilloscope to a train receiver's detector at a point before the signal is digitalized or limited.
d. The train will stand so that its front end is ten feet in approach to the impedance bond on the track circuit's entering end.
e. To be acceptable, the effective voltage level of the signal will be less than 75 percent of the minimum voltage level, at that point, required to hold any frequency detector relay or any code detector relay energized. This check will be made with the transmitter set to produce normal operating current in the rails and the train's receiver set for maximum sensitivity.
f. At a minimum, one track circuit for each combination of frequencies and modulation rates will be tested.

5. Each track circuit will be tested for shunting sensitivity. This test will be performed by connecting an oscilloscope to the track circuit receiver's detector at a point before the signal is digitalized or limited.

a. A 0.25-Ohm shunting strap will be placed across the rails ten feet from the transmitting bond.
b. To be acceptable, the effective voltage level of signal will be less than 75 percent of the minimum voltage level, at that point, required to hold the track relay in an operated state. This test will be performed after the final track circuit adjustment has been made.

L. Interlocking Loop Circuits

1. The purpose of this procedure is to check that only the proper train carrier frequency transmitters are turned on for the route initiated. This test will also verify that all other loop circuits have sufficiently low signal levels to prevent a false speed command from being received on a train overrunning an interlocking signal indicating stop.

2. This test will be performed by initiating all possible routes, simulating train movements by use of shunts, and measuring current levels of train frequency carriers at all entering points for each track circuit in each route.
3. All train frequency current levels will be recorded and submitted to the CTA.

M. Speed Command Loops

1. This test procedure is to ensure that only the proper inductively coupled ATP speed commands in AC track circuit areas meet the manufacturer's recommended levels and are turned on for the route initiated.
2. This test will be performed by initiating train movement by use of shunts and measuring current levels of train frequency current in each route.
3. All train frequency current levels will be recorded and submitted to the CTA.

N. Receiver Point Loops

1. The purpose of this test is to ensure that the proper shunting of the high definition receiver point loops and ATP speed commands meet the manufacturer's recommended criteria.
2. This test will be performed by use of shunts simulating train movement.
3. All track frequency levels will be recorded and submitted to the CTA.

O. Wayside Train Detection and Protection Circuit Tests

1. Each track circuit will be tested to determine that the speed commands transmitted by that track circuit conform to the speed commands shown on the approved drawings.

    a. An CTA-provided train will be used to test all cab signals for each track circuit.
    b. All control lines for the approved block layout, including all modified control lines for existing tie-in track circuits, will be tested.

2. To perform this test, the train will be located on the track circuit being tested. Other shunting straps will be used to shunt the track circuits to provide the required speed command as each track is shunted.
3. With the train in the track circuit under test, the track circuits ahead of the track circuit under test will be shunted in a way to simulate the movement of a maximum length train and a minimum length train.

    a. If an interlocking signal is in the control line for the track circuit under test, the test will be performed with the interlocking signal indicating

stop and with the interlocking signal giving an indication other than stop.

b. If a facing point switch is in the control line of the track circuit test, the test will be performed with the switch in both positions.

4. To be acceptable, the cab signal displayed within the test train will convey all individual speed commands shown by the control line for the track circuit under test.

P. Switch-and-Lock Movement

1. Tests will be required on all electric switch and lock movements. These tests will include, but not be limited to the following:

a. A continuity check of field wires to switch and lock movements to verify proper nomenclature in junction boxes and switch circuit controllers.

b. Adjust throw bar so that proper tension is placed on switch points in both directions.

c. Manually crank/lever switch machine to the far switch point and adjust lock rods and point detector rods to allow switch machine to lock up with no obstruction. Repeat above for switch machine cranked/levered to the near switch point.

d. Turn on switch machine power and call switch machine normal and observe in field that switch machine corresponds to position called and observe in wayside instrument housing that proper switch correspondence relay is picked up.

e. With switch machine called normal, check gaps on circuit controller contacts to see that they meet equipment specifications. Operate machine reverse and repeat.

f. Break down each contact in switch circuit controller and observe that proper switch correspondence relay drops. Repeat this procedure for both positions of the switch.

g. Place ammeter in series with motor control energy and adjust clutch such that it causes overload relay to pick up in less than ten seconds with 1/4-inch obstruction in switch point. Record current reading. Repeat for opposite position.

h. Insert the hand crank and observe switch mechanism cannot be operated by power. Remove crank, restore latch and verify that switch mechanism can be powered.

i. Using a 3/8” and 1/4” obstruction gauge, perform locking and indication tests for the normal and reverse points.

Q. Train Stop Layouts

1. The tests for the train stop layouts will include but not be limited to:

a. Mechanical distance and arrangements will be checked against the approved installation drawings. The train stop indication contacts will be adjusted so that the NVP will be de-energized when the trip arm is lowered ¼" below the full normal position. The RVP will energize when the trip arm is within ½" of the full reverse position.
b. Contact closure and pressures will be checked to be in agreement with the manufacturer's requirements.
c. Checks will be made to ensure that the installed electric train stops operate at the manufacturer's recommended current requirements.

i. Verify that the hold down circuit functions properly and reduces the motor current..

R. Signal Layouts

1. Tests will be performed on all signal layouts. These tests will include, but not be limited to the following:

a. Continuity checks of field wires and verification of all nomenclature.
b. Apply energy to signal lighting circuits and adjust all voltages to nominal array rating.
c. Break down signal clearing relay contacts and observe that proper signal aspect is displayed.
d. Depress trip release and verify proper operation.
e. Sight signals for maximum visibility.

S. Route Selector Layouts

1. Tests will be performed on all route selector layouts. These tests will include, but not be limited to the following:

a. Continuity checks of field wires and verification of all nomenclature.
b. Lighted indicators correspond to available routes.
c. Route requests and cancel via the wayside selectors are inhibited unless location is in automatic mode of operation and track circuit directly in approach to signal is occupied.

T. Line Circuits

1. The purpose of this test procedure will be to verify the integrity of line circuits between wayside relay locations. These tests will include, but not be limited to, the following:

    a. All nomenclature will be verified and line circuits tested for continuity.
    b. Open and close the controlling relay contacts of the line circuit and verify the proper response of the relay at the other end of the circuit.

U. Traffic Locking

1. The purpose of this test is to verify the operation of traffic locking between adjacent interlockings. These tests will include, but not be limited to, the following:

    a. Traffic direction will be tested by first establishing each direction of traffic and then sequentially dropping each individual track circuit from headlock to headlock and observing that traffic cannot be reversed.
    b. Once traffic is established an attempt will be made to clear all possible conflicting routes and ascertaining that neither the conflicting route can be cleared nor can the established direction of traffic be affected.
    c. Each block repeater relay will be tested to determine that it follows all the proper track relays dropped in wayside instrument housings.
    d. With an established direction of traffic, the controlled signal governing entrance to that particular route will be put to stop when approach track circuit is occupied.

        i. Establishing traffic in the opposite direction will not be possible until a predetermined time has passed.
        ii. This predetermined time will be as indicated on the approved plans. It will be ascertained that approach or time locking is effective for this test.

    e. Both the normal and reverse directions will be tested in accordance with the above.

V. Interlocking and Control Point Tests

1. A detailed list of the tests and complete test procedures will be submitted for the approval of the CTA to establish safe and proper operation of interlockings.
2. The test sequence will be designed to test each function for correct performance in accordance with these Specifications and the approved plans. Furthermore, the test sequence will include simulated unusual conditions to determine that the interlocking circuits will respond in a safe and desirable way.
3. The functions to be tested will include, but not be limited to the following:

a. Approach locking.
b. Time locking.
c. Route locking.
d. Verification of timing of time releases.
e. Detector locking.
f. Signal operation in accordance with route and aspect charts.

i. Initiation and cancellation of routes in the automatic and manual modes of operation.

g. Interconnection with existing signal systems.
h. Interconnection with existing interlockings.

4. Time tests will be as follows:

a. Loss of shunt.
b. Approach and time locking.
c. Emergency traffic release and track locking.
d. Emergency switch release.

5. Overrun protection will be tested to ensure that with a route lined and the accepting train shunting the first interlocking detector track circuit downstream of the controlled signal governing the lined route, the cab signal train control energy being transmitted to the track will be shut off when another train overruns an interlocking signal protecting a conflicting route.

W. Route Security Locking

1. Each route will be tested for route security. This test will be made by establishing the routes and falsely picking the route check relay for each opposing or conflicting signal while observing that the associated signals stay at STOP and the associated signal clearing relays remain de-energized.

a. Route security test procedures within microprocessor systems will be submitted by the Contractor, and tested in accordance with the approved procedures.

X. Snowmelter Layouts

1. Tests will be required on all electric track switch and train stop snowmelter layouts. These tests will include but not be limited to the following:

a. Continuity check all field wires as shown on the approval plans and verify proper nomenclature.

b. Apply energy to control relay and observe that it picks up.

c. Turn on controls and verify that the heating elements are operating and indicating they are operational, including:

i. Proper contactor applying and removing power from heating element.
ii. Designated fuse applying and removing power from element.
iii. Door indicator LED light with all contactors closed and dark with any individual contactor open.

d. Verify that all current sensors operating properly and individually fault under the following conditions:

i. Break in heater element feed or return connection cables.
ii. Opening of 10A feed end fuse to any heater feed.
iii. Failure of contactor to close.
iv. Opening of 5A low voltage fuses.

e. Test all safety devices included in the snowmelter layout:

i. Door switch.
ii. Test switch.

f. Test local control on/off.

g. Test remote control on/off.

h. Test location to location cascade of on/off control.

Y. Control Office (Racine) and Maintainer Workstation(s) to Wayside Interface

1. Upon completion of the wayside tests, a simulated system test will be performed to ensure continuity of operation of wayside equipment from the supervisory control system.

a. This test will consist of controlling all office wayside functions from a simulated supervisory control console and the transmission back to the simulated console of all indications from the field stations.

Z. Worker Ahead Warning System Tests

1. The worker ahead warning system tests will consist of checking the operation of:

a. Control box switches (in every combination of switch positions).
b. Indication lighting.
c. WA lights.
d. Verification of cab signal system speed downgrade when system is activated.

AA. Automatic Vehicle Identification (AVI) System Tests

1. The AVI system will be tested to verify the following:

a. Verification that the equipment is installed and wired in accordance with the approved design and manufacturers recommendations.
b. Proper routes are registered in the interlocking system logic when a transponder passes over the wayside reader within the set design and manufacturers parameters.
c. The wayside reader is sufficient distance from the interlocking to allow signal clearing without cab signal degradation.
d. AVI route requests are stored when interlocking is in the manual mode of operation.
e. AVI requested routes are acted upon in the correct sequence when the interlocking is in the automatic mode of operation.

BB. Emergency Control and Indication Panel Tests

1. The emergency control and indication panel tests will consist of controlling the wayside functions from the local or remote panel. All controls and indications on the respective panel will be checked.

CC. System Tests

1. Tests will be conducted to verify the integrity of the installed signal and interlocking system. These tests will also include all tie in interface signal control and approach locking circuitry for all signaled tracks approaching and abutting the contract limits of this Contract.

a. For interlockings, this test will be performed using the local control panel.
b. Other system tests will include, but not be limited to, the following:

i. With traffic lined normal, all possible routes will be lined. A 0.25 ohm shunt will be placed sequentially on each track circuit in the route to simulate train movement. The Contractor will verify that all wayside signals are displaying the proper signal aspects as indicated on the approved plans.
ii. All aspects observed during the progression of this test will be recorded.
iii. Traffic will be established in the reverse direction, for each route between adjacent interlockings, and the system will be tested in a similar manner as described for normal direction operation.
iv. Verification that cab signal energy code rates are in agreement with wayside signal aspects will also be made, and results recorded, for all

routes shown on the approved plans.

v. All design changes found necessary to obtain proper operation will be submitted to the CTA for approval.

DD. Operation Recorders

1. Operation recorders will be tested in accordance with the manufacturer's recommended test procedures and the approved field test procedures. This test will include, but not be limited to the following:

a. Verification of indication wires for the proper input locations.
b. Verification of the proper printed output for each input.
c. Clarity of printed outputs.

EE. Power Tests

1. The following power tests will be made and recorded:

a. The voltage of the main power feeders will be measured and recorded.
b. A check of all fuses will be made for correct size and type.
c. All power supplies will be checked for correct setting and quantities.
d. Buss to buss checks will be made to determine that no shorts, crosses or grounds exist.

FF. Ground Detector Tests

1. All ground detectors will be made operational (free from grounds) prior to performing this test. The following will be tested and results recorded:

a. Simulate a ground condition on both the positive and negative sides of each power supply provided with a ground detector and verify:

i. As the simulated ground is introduced the ground detector is tripped and alarm sounds.
ii. When simulated ground is removed the ground detector will reset and remain set and the alarm silent.

b. Repeat for each power supply/ground detector combination.

GG. Transfer Switch

1. The following will be tested and results recorded:

a. Both normal (inverter) and reserve (commercial power) sources available. Check indications and affected circuits.
b. Open normal source and verify transfer. Check indications and affected circuits.

c. Close normal and verify transfer back to normal.
d. Open reserve source and verify indications.
e. Open normal source and verify total power loss.
f. Close reserve source and verify transfer to reserve.
g. Close normal source and verify transfer back to normal.

HH. Dynamic Braking Tests

1. The Contractor will perform dynamic braking tests for selected speed commands for selected control lines for the approved block layout.

    a. Tests will be performed for all track circuits on the RPB fly-over.
    b. Tests will be performed for all control lines where the calculated safe braking buffer is less than fifty feet.

        i. Safe Braking Buffer is defined as the difference between the calculated safe braking distance including all safety factors and the available safe braking distance.

2. A derated train and train crew will be provided by the CTA for the dynamic tests. Scheduling and arrangements of the tests, including coordination with the concurrent contracts, will be by the Contractor.

    a. The Contractor will provide the CTA a minimum of four weeks advance notice to allow the CTA to prepare the derated train.

3. All field personnel and equipment required to place shunts, measure speeds and distances, record results, and the supervision to perform the tests will be by the Contractor. The CTA may be present to observe the testing.
4. Prior to the tests, the Contractor will submit a detailed, step-by-step test procedure to be followed. Submittal of the test procedure will be sufficiently in advance of the test date to allow CTA review and comments to be incorporated.
5. Each block will be shunted at the entering end of the block for the direction being tested. The test train will be located at a point to allow the test speed to be obtained. With the train approaching the shunted block at maximum speed, record the speed and location of the block boundary where safe braking is initialed, the location where the train stops, and the distance to the shunt.
6. Should any block layout modifications be required due to the results of the dynamic tests, the modified blocks will be retested by the Contractor at no additional cost to the CTA. The costs for train crews and preparation costs for any retests will be borne by the Contractor.

II. Ancillary Signal House/Room Equipment, Alarms and HVAC System Tests

1. House/room intrusion and fire alarms will be tested in accordance with the approved design, manufacturer's recommended test procedures and the approved field test procedures. Tests will demonstrate and document results of the following:

    a. Activation and de-activation of the intrusion alarm.
    b. Activation of the fire alarm system and at what point the fire repellant would be released.

2. The house/room heating, ventilation and air conditioning system will be tested in accordance with Manufacturer and Contractor provided procedures submitted to and approved by the CTA.

    a. Testing will demonstrate interoperability of all components in satisfying all requirements of the HVAC system stated within these specifications.

3.06 DISCREPANCIES

A. The Contractor will prepare Discrepancy Sheets to accompany each factory test section and each field installation and test section. These forms will be located at the end of each test section. All discrepancies found during testing will be noted on these forms.

1. There will be one discrepancy sheet for each discrepancy uncovered within a test section. The sheet will contain the following minimum information:

    a. Test section and subsection.
    b. Detailed description of discrepancy.
    c. Detailed description of corrective action taken to rectify discrepancy.
    d. Printed name and signature of individual that uncovered discrepancy and date.
    e. Printed name and signature of individual that corrected discrepancy and date.
    f. Printed name and signature of individual witnessing corrective action and date.

2. If no discrepancies are found during a test, a single form should be included at the end of the test section with notation that no discrepancies had occurred. The sheet should then be dated and notarized with printed name and signature of the test person in charge and CTA’s witness to the tests.

B. In addition to discrepancy forms accompanying tests, the Contractor will maintain a separate up-to-date Master Discrepancy Log book for each location.

1. This separate discrepancy log for each location will contain a copy of all discrepancy sheets as would be found in the field.
2. The log will be maintained in the order of testing.
3. A single “quick look” overview sheet will be maintained at the beginning of each log showing each test section along with the number of discrepancies and status of each.
4. Each locations discrepancy log will be submitted for review by the CTA on a weekly basis and a copy available for review within 24 hours of request.

C. No tests will be considered complete until all discrepancies have been resolved to the satisfaction of the CTA.

END OF SECTION

SECTION 34 71 24
ROADWAY SIGNING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Book 1 Terms and Conditions for Construction, Book 2 Instructions and Execution Documents, Additional Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This work shall consist of the fabrication, furnishing, and mounting of signs and sign poles of various sizes and lengths to the project locations as per the Contract Drawings and as directed by the Commissioner. Standard traffic signs designated by letters and numbers must be according to the MUTCD. Standard traffic signs must be according to the Standard Highway Signs, except where otherwise specified by the Commissioner. Non-standard signs must be according to the Chicago Sign Manual and Detailed Drawings included in the Plans. Pole installation shall be either by dig method or drill method as shown on the Contract Drawings. The poles installed using dig method shall be 10 feet and 8 inches in length and the poles installed using drill method shall be 9 feet and 8 inches in length. The cost of wedges, sleeves, pole bases and all other required hardware to install poles is included in the cost of these items. As part of the work under this item, the Contractor must supply and install all hardware required for a complete installation including horizontal bracing channels, bands, bolts, washers and nuts.

1.03 RELATED SECTIONS

A. Work under these items shall be performed in accordance with the requirements of Section 720 of the Standard Specifications, the latest version of the City of Chicago Department of Transportation Field Manual For Sign Installation, and the Illinois Department of Transportation Manual on Uniform Traffic Control Devices (MUTCD), 2003 Edition; except as herein modified.

B. Except as modified herein, the work must be performed in accordance with the requirements of Section 108.2 of Special Conditions for Transportation Construction, and applicable Additional Special conditions, as well as the requirements of the General Conditions, Division 1, and this Section.

1.04 REFERENCES

A. Standard Specifications for Road and Bridge Construction, Illinois Department of Transportation (IDOT), April 1, 2016, or latest edition.

PART 2 - PRODUCTS

2.01 MATERIALS – SIGN PANELS

A. Sign Base - Flat Aluminum Base: Flat aluminum sign base material must be Type 5052 H38/Mill flat sheet and shall meet the requirements of Article 1090.01 of Standard Specifications. Mill certification sheets must be submitted with each order of fabricated signs. The sign panel thickness must be according to Article 1090.02 of the Standard Specifications.

B. All sign-bases used for non-reflective signs shall be powder coated. The sign base material must withstand exposure to temperatures up to 350 degrees Fahrenheit (as experienced during a powder coating process) and maintain all inherent physical characteristics. No warpage or other deformation must result from exposure to said temperature, and the bowing, when laid on a true flat surface must not exceed 1/16 inch per foot in length or width.

C. Sign Base Coating - Powder Coat Finish: Powder coatings of aluminum sign blanks must be used as the substrate for applying a reflective sheet of either heat applied or pressure sensitive adhesive, to be followed by direct application of message inks, pastes or baked enamel paints either by printing or silk screening processes and then receive a protective overlay film.

D. Electrostatically apply powder coat of selected color and bake in controlled high temperature oven to assure a smooth, hard satin finish.

E. Powder coating must be applied to both sides of sign blanks, including the back of one sided signs. Powder coating type must be a TGIC-Polyester. The powder coat color must be the same as the sign background color, as defined in the MUTCD.

1. The powder coating process must include a negative electrical charge administered to the sign blanks, a five (5) stage washing process, an oven dry process, a cooling period, a spray application of polyester coating, which has been given a positive electrical charge to strengthen the bonding, a baking process as recommended by the paint vendor, at a temperature no higher than 350° and a cool down period.

    a. Coated surface must be free of visual defects such as orange peel, craters, dust, discoloration, etc.

2. Application: Electrostatic Spray, cold.

    a. Substrate: 0.08 inch sheet aluminum, alloy 5032 H38.
    b. Pretreatment: Chromium chromate, Alodine as recommended by the coating.
    c. Manufacturer.
    d. Cure Schedule: As recommended by the coating manufacturer.
    e. Film Thickness: 2.0-2.5 Mils, or as required to cover.

3. Colors: Safety Yellow, Red, Brown or White. The color of the powder discoloration, etc. coating must match the color of the sign background.

F. Powder coating must be tested and certified for the following properties:

TEST	METHOD	COATING PROPERTIES
*ASTM D3451 (18.3)	Specific Gravity	3.30±0.06
Theoretical Coverage		147±4 ft,°/lb/mil
*ASTM D3451 (13)	Volatile Content During Cure	<.5%
Maximum Storage Temp.		75°F
ASTM D623	Gloss at 80°	85+
Visual Comparison	PCI Power Smoothness	7
*ASTM D2454	Overbake Resistance, Time	100%
ASTM D3383	Pencil Hardness	H-2H
ASTM D2794 (modified)	Dir/Rev Impact, Gardner	40/10 in/lbs
ASTM D3359B	Adhesion, Cross Hatch	5B Pass
ASTM D522	Flexibility, Mandrel	1/8 In. dia. no fracture
ASTM D117	Salt Spray	1,000 hrs
ASTM 04585	Humidity	1,000 hrs

*Above properties are typical, and vary with the product used.

G. Sign Face Materials

1. Non-reflective signs: The non-reflective material must conform with Section 1091.01 and 1091.02 of the Standard Specifications.
2. Reflective Signs: The reflective material must be Type A (glass spherical lens) as specified in Sections 1091.01 and 1091.02 of the Standard Specifications or Type AZ (Prismatic Retroreflective Sheeting) as specified herein. In accordance with the warranty requirements defined hereinafter, between the end of seven and ten years after installation, the coefficient of retroreflection must be greater than or equal to the percentages shown below for .2o and .5o observation and -4o and +30o entrance angles.

    a. Type A Sheeting: Initial requirements, for Type A sheeting, are as shown in Table 1091-2 of the Standard Specifications. For screen printed transparent colored areas or transparent colored overlay films on white sheeting, the coefficients of retroreflectivity must be greater than or equal to the values for the corresponding color shown in the table below.

Sheeting Color	Min.Coefficient of Retroreflectivity After Seven Years (% of Initial Requirements)	Min. Coefficient of Retroreflectivity After Ten Years (% of Initial Requirements)
White	85%	80%
Yellow	85%	80%
Green	84%	80%
Red	84%	80%
Blue	85%	80%

Brown	83%	80%

H. Silk Screen Inks: The silk screen inks must meet the recommendations of the manufacturer of the sign background material and be applied according to the ink manufacturer's recommendations. Inks must be suitable for exterior applications with proven weather resistant and color retention properties. Ink types must include opaque, semi-transparent and transparent. The Contractor must provide specific types as required for type of applications indicated, as selected by Owner's Representative and as shown on approved shop drawings. The Contractor has the option to use vinyl graphic marking film, 3M Scotchcal in lieu of silkscreen inks. The Contractor must provide certification that the material meets or exceeds the requirements specified for silkscreen inks, including warranty requirements, and is compatible with sign materials. The color of the graphic marking film must be the same as specified for silkscreen inks.

I. Type AZ Sheeting

1. Type AZ sheeting shall consist of a flexible, colored, cube corner prismatic retroflective material having a smooth outer surface. It shall have a protective liner that is easily removed and a pre-coated pressure sensitive adhesive (Type 1) capable of being applied to the aluminum base without additional adhesive coats on the reflective sheeting or substrate material.
2. The sheeting shall be uniform in color and devoid of streaks throughout the length of each roll. It shall conform to the latest appropriate standard color tolerance chart issued by the U.S. Department of Transportation, Federal Highway Administration or through instrumental color testing. The diffuse day color of the reflective material shall conform to the following tables.
3. Transparent colors screened on white sheeting shall have initial `R' values not less the 50 percent for yellow and red, and 70 percent for green, blue and brown of the 0.2° observation angle/-4.0° entrance angle values shown in Table II for the color being screened.
4. Nighttime reflected colors shall be uniform, devoid of streaks, and appear substantially the same as daytime colors throughout the warranted service life.
5. Sheeting used for side by side overlay applications will require closer day/night color tolerances.

Color Specifications Limits (Daytime)
Type AZ

Color	Reflectance 1		2		3		4		Limit Y (%)	
	X	Y	X	Y	X	Y	X	Y	Min.	Max.
White	0.305	0.305	0.355	0.355	0.335	0.375	0.285	0.325	40	-
Yellow	0.487	0.423	0.545	0.454	0.465	0.534	0.427	0.483	24	45
Orange*	0.583	0.416	0.523	0.397	0.560	0.360	0.631	0.369	30	-

Red	0.690	0.310	0.595	0.315	0.569	0.341	0.655	0.345	3	15
Blue	0.078	0.171	0.150	0.220	0.210	0.160	0.137	0.038	1	10
Green	0.030	0.398	0.166	0.364	0.286	0.446	0.201	0.794	3	9
Yellow/* Green	0.387	0.610	0.460	0.540	0.421	0.486	0.368	0.539	60	-
Yellow*	0.521	0.424	0.557	0.442	0.479	0.520	0.454	0.491	40	-

* FLOURESCENT COLOR

6. The four pairs of chromatically coordinates determine the acceptable color in terms of the CIE 1931 standard calorimetric system measured with standard illuminate D65.
7. The reflective intensity shall be determined by the procedures described in ASTME 810 except that values shall be met at both 0° and 90° or the 45° rotation angles without averaging.
8. Minimum Coefficient of Retroreflection
9. Average Candelas/Lux/sq m (candelas/foot candle/sq ft) of Material

Type AZ
(0 degree Rotation Angle)

	Observation Angle 0.2		Observation Angle 0.5	
	Entrance Angle		Entrance Angle	
Color	-4	+30	-4	+30
White	430	235	250	170
Yellow	350	140	200	140
Yellow*	240	150	165	75
Yellow/ Green*	325	200	235	105
Green	45	24	25	19
Blue	20	11	10	7

* Fluorescent Colors

10. The sheeting surface shall exhibit a 85° gloss-meter rating of not less than 50 when tested in accordance with ASTM D 523.
11. Processed and applied in accordance with recommended procedures, the sheeting shall be weather resistant. Following cleaning, the applied sheeting shall show no appreciable discoloration, cracking, streaking, crazing, blistering, or dimensional change and shall exhibit not less than 80 percent of the brightness values shown in Tables II and III when exposed to 1,000 hours of accelerated weathering.
12. The test specimens shall be cleaned by immersing in 5% hydrochloric acid solution for 45 seconds, then rinsing with water and blotted dry with a soft clean cloth. The cycle used shall consist of 8 hours of light at 60° C followed by 4 hours of condensation at 40° C.

13. When tested according to ASTM D 4956, the sheeting shall not shrink in any dimension more than 1/32 inches in 10 minutes and not more than 1/8 inches in 24 hours.
14. After conditioning for 24 hours at 22± 4°C at 50± 5% relative humidity, with the protective liner removed, the sheeting shall show no cracking when tested by bending over a 1/8in mandrel in one second (adhesive coated with talcum power to prevent sticking to the mandrel).
15. A single roll shall not contain more than 4 splices per 50yd length. The sheeting shall be overlapped not less than 3/16".
16. The sheeting shall form a durable bond to smooth corrosion and weather-resistant surface and adhere securely at temperatures of -35° to 70°C. The pre-coated adhesive, 48 hours after application, shall be elastic enough to resist shocking off when struck at -23°C and strong enough to resist appreciable peeling. The bond shall be sufficient to support a 1.75lb weight attached to the free end of a specimen and allowed to hang free from an angle of 90° to the panel surface for 5 minutes without peeling more than 2" as outlined in the test for adhesive backing in Federal Specification LS-300.
17. Sheeting, with Type I adhesive, used for manufacturing cut-out legends and borders shall provide sufficient position ability during the fabrication process to permit removal and re-application without damage to either the legend or sign background and shall have a plastic liner suitable for use on bed cutting machines. Thereinafter, all other adhesive and bond requirements contained in the specification shall apply.
18. The thickness of the sheeting without protective liner shall not be more than 0.025".
19. The sheeting shall permit cutting and color processing in accordance with the sheeting manufacture's recommendations at temperatures of 15° to 38°C and relative humidity of 20% to 80%. The sheeting shall be heat resistant and permit forced curing without staining of applied or unapplied sheeting at temperatures recommended by the manufacturer. The sheeting shall be solvent resistant and capable of being cleaned with VM & P naphtha, mineral spirits, and turpentine.
20. Stored under normal conditions and temperatures, the sheeting as supplied shall be suitable for use for a period of at least two years. With the exception of the mandrel test values specified, the sheeting shall continue to be pliable and workable.
21. The sheeting shall have a distinctive overall pattern in the sheeting unique to the individual manufacturer. If material orientation is required for optimum retroreflectivity, permanent marks indicating direction of orientation shall be incorporated into the face of the sheeting throughout the roll length. They shall be readily visible to the sign fabricator. Neither the overall pattern nor the orientation marks shall interfere with the reflectivity of the sheeting.
22. Documentation for roll materials shall contain a written declaration from the sheeting manufacturer stating that material storage conditions, fabrication and application processes, completed sign storage facilities, and packaging and shipping methods at the Department's Sign Shop facilities are acceptable and comply with applicable material warranty conditions.
23. Rolls of the widths and lengths specified on the purchase order shall be supplied on a 3 inch I.D. fiber core the same width as the sheeting. The

rolls shall be packed snugly in individual corrugated fiberboard boxes in such a manner that no damage or defacement will occur to the reflective sheeting during shipment or storage. Rolls of 12 inches or less in width may be multiply packaged. Both ends of each box shall be clearly labeled as to type, color, adhesive, manufacturer's lot number, date of manufacture, and vendor's name.

24. The vendor shall provide, at no cost to the user, the following incidental items for fabrication, packaging and installation of Type AZ roll good material. Quantities will be requested by the user and will not exceed those appropriate for use of the Types AZ material purchased.

    a. Opaque Silk Screen Ink - Black (Single Component, Low odor).
    b. Transparent Silk Screen Ink - All colors (Single Component, Low Odor, Clear Coat not required, 8 Hour Maximum Dry Time).
    c. Ink Thinner.
    d. Slip Sheeting (Perforated) 24in, 30in, 36in, and 48in widths by 100yd rolls.
    e. Nylon Protective Mounting Washer 1/16in Thick by 3/8in ID by 7/8in OD.
    f. Packing paper 24in, 30in, 36in, and 48in widths by 100yd rolls.

J. Type AZ sheeting used for permanent traffic control signs shall be guaranteed by the manufacturer to comply with the following:

1. Typed AZ sheeting processed and applied to new or refurbished aluminum sign blank material shall perform effectively and maintain a uniform day/night color for a period of ten (10) years after erection.
2. The sheeting shall be considered unsatisfactory when it has deteriorated due to natural causes to the extent that any of the following conditions exist:

    a. The sign has been determined by the purchaser to be ineffective when viewed from a moving vehicle under normal day or night driving conditions.
    b. Permanent streaking, cracking, or color variations (either day or night) develop on the sign surface.
    c. The reflective value of a sign(s) at the 0.2° observation angle/-4.0° entrance angle is below the value shown in the following table. The reflective value shall be determined by averaging random reflective measurements * in accordance with the following criteria.

Sign Size (Square Feet)	1-50	51-200	over 200
Min. Random Measurement/Sign (Ea.)	5	9	15
Max. Readings Below Table II (Ea.)	1	2	3

K. Reflective Measurements will be made with a calibrated hand held retroreflectometer after wiping with a soft dry cloth to remove any dust, lent, or road film from the area to be measured.

L. The purchaser will date all signs by month and year when they are fabricated.

1. This guarantee will be prorated accordingly for signs erected more than one year after fabrication.

M. Warranty Criteria

1. Minimum Coefficient of Retroreflection
2. Candelas per Lux per Square Meter of Material
3. Observation Angle 0.2 Degree - Entrance Angle -4.0 Degrees

Type AZ

	Initial	(1-7yrs)	(8-10yrs)	Initial	(1-7yrs)	(8-10yrs)
White	370.0	295.0	260.0	N/A	N/A	N/A
Yellow	300.0	240.0	210.0	175.0	140.0	100.0
Green	45.0	36.0	31.0	31.0	22.0	16.0
Blue	22.0	17.0	15.0	14.0	12.0	10.0
	325.0	260.0	190.0	N/A	N/A	N/A
Yellow/Green*						
Yellow*	240.0	192.0	165.0	120.0	96.0	80.0
Red	98.0	78.0	68.0	68.0	57.0	51.0

*Fluorescent Color
** (1-3yrs)

N. When Type AZ sheeting does not perform in accordance with the guarantee, the manufacturer shall provide replacement signs during the first seven years after the sign is erected.

2.02 MATERIALS – SIGN POSTS

A. Materials: The material for the poles furnished must be hollow steel tubes, 2 - 3/8 inches outside diameter, conforming to ASTM A500 Grade B and coated for resistance to corrosion and outdoor weathering. Nominal wall thickness of the pole must be 0.08". The sign pole must be formed to the size and type specified in the Contract Drawings. Holes must be drilled prior to coating to prevent indentations and dimples in the poles.

B. Finish: The poles must be galvanized, straight and have a smooth, black, uniform powder coating finish as specified below. The interior of the sign poles must be coated with a minimum of an 81% zinc rich primer. The exterior of the poles must be galvanized with material conforming to AASHTO M 120 with a minimum weight of 1.00 ounce per square foot. The weight of the exterior galvanizing may be reduced to 0.65 ounces per square foot of High Grade material conforming to AASHTO M120 if applied with a chromate conversion

coating and a clear high performance organic polymer coating. Powder coating of the poles and extensions must meet the following requirements:

1. Color: Vulcan Black Polyester
2. Product No.: PFB-401-S6
3. Cure: 400F-18 minutes PMT
4. Resin type: Polyester
5. Gloss: Medium

C. Pretreatment Process:

1. Cleaning: All parts must be cleaned utilizing spray washers and an alkaline cleaner to remove any remaining grease, dirt, or other contaminants.
2. Rinsing: All parts must be spray rinsed in a continuously overflowing rinse stage to remove any remaining cleaning solution.
3. Phosphating: All parts must be spray phosphate with a heated phosphate solution to provide a transition coating between metal and powder.
4. Rinse: All parts must be spray rinsed in a continuously overflowing rinse stage to remove any remaining phosphate / sealant solution.

D. Powder Coating Process:

1. Drying: All parts must be preheated to totally eliminate moisture and prevent off gassing of casting.
2. Powder Coating: A premium TGIC polyester powder must be electrostatically applied to provide a uniform coating to a thickness of 1-3 mils (1 mil minimum). To achieve proper mil thickness, the powder must be applied with one application. The manufacturer must be responsible for ensuring proper adhesion to the metal surface.
3. Curing: All parts must be heated to the exact time and temperature requirements, recommended by the powder coat material manufacturer, in precisely controlled gas ovens.

E. Sleeve and Locking Wedge

1. Pole sleeve (pipe socket): Material must be hollow steel tubes conforming to ASTM A500 Grade B or ASTM A501, and galvanized according to AASHTO M111, nominal wall thickness of 0.109", 2- 5/8 inch inside diameter that allows for a minimum of 13-1/4 " of sign pole to nest inside the sleeve. The overall length of pole sleeve must be 27". A drawing detail as shown in the Appendix I shall govern.
2. Locking wedge: Material shall be 11 gauge steel tube conforming to ASTM A500 Grade B or ASTM A501 and galvanized according to AASHTO M111. The locking wedge shall be contoured to fit between the steel pole and the 27-inch sleeve. A drawing detail as shown in Appendix I shall govern.

F. Sign Pole Base

1. The sign pole base furnished under this contract includes a carriage bolt, tamper-resistant nuts, and anchor bolts with nuts. The finished casting must be free from burrs, cracks, voids, or other defects.

2. Support base: Twelve-inch diameter, aluminum -zinc alloy casting per ASTM A197. The casting must have the words "City of Chicago" cast in relief as shown in the drawings provided in the Appendix I of these specifications.
3. Bolt washers and nut: Stainless steel as specified in Article 1006.31a of the Standard Specifications. Include a ½" x 4-1/2"carriage bolt with two 1"flat washers and a ½"-13 full height hex nylon locknut.
4. Anchor Bolt: Galvanized steel expansion anchors conforming to Article 1006.09 of the Standard Specifications. Red Head #1236 (½"x 3-3/4"). Furnish three (3) per each sign base provided.
5. Finish: Powder coat to minimum 1 mil thickness with satin black polyester finish.

2.03 MATERIALS – SIGN PANEL MOUNTING

A. The sign mounting hardware for the signs furnished under this contract includes brackets, holders, bands, bolts, nuts, washers, screws and all other necessary devices to connect sign assemblies and to mount signs to new posts, existing light or traffic signal posts, or adjacent structures. Bolts and nuts must be tamper-resistant.

B. Sign Hardware for center mount on sign poles and light poles: Stainless steel sign bracket, 5/16"x 5/8" stainless steel hex head flanged bolt, and 3/8"x 3/4"x 1/16" stainless steel washers. 5/16"x 3.5" stainless steel socket head screw with 1-1/2"x1-1/4" sign bracket, two flat washers and nylon locknut per fastener assembly as per the installation detail in the Appendix I. Mounting detail for back-to-back sign mount on light pole is provided in Appendix I.

C. Sign Hardware for flag or center mount, banded to light poles: Two 0.75 inch x 0.020 inch stainless steel band fasteners.

D. Sign hardware for center mounting: One stainless steel button head socket head screw with two flat washers and nylon locknut per mounting bracket, to attach mounting bracket to pole. Two button head socket head screws with four flat washers and nylon locknut per mounting bracket to attach sign to the sign bracket.

E. Sign Hardware for flag mount on light pole or sign pole: Cast aluminum brackets per the drawing in the Appendix I. The sign mounting brackets must be an aluminum-zinc alloy. The casting must be tenzaloy with a multi-curve back design. The sign brackets must be powder coated with a satin black finish, Product 311 B, with Cure 400F - 18 minutes PMT, TGIC polyester. A drawing of this bracket is included in the Appendix I. Mount the brackets to a sign pole with a 3" x 5/16" stainless steel bolt and nylon lock nut.

F. Mount the bracket to a light pole by banding with 0.75 inch x 0.020 inch stainless steel banding. Attach the sign to each bracket with two 1-1/4" x 1/4" stainless steel bolts and nylon locknut.

G. Miscellaneous: All stainless steel screws, bolts, washers and nuts must conform to the requirements of Section 1006.29(d) of the Standard Specifications. All bolts and nuts must have National Coarse Thread.

2.04 MATERIALS SAFETY-SIGN PANELS

A. All suppliers for roll material shall furnish at no cost, any product information, Material Safety Data Sheets, bulletins, technical service required to use the sheeting, and the name(s) and telephone number(s) of qualified service personnel that may be contacted during normal working hours to address any product related problems.

B. Additional Sign Face Materials Requirement: Contractor must certify that all materials used in the fabrication of signs (substrate material, inks, films, overlays) are compatible with one another under conditions of service and application, as demonstrated by the manufacturer based on testing and field experience, and that the materials comply with these specifications.

C. City of Chicago Identifier: In addition to the above requirements, signs must have "CITY OF CHICAGO XX" logo screened at the bottom center or top right corner of the sign where XX represents the last two digits of the year of sign manufacture.

2.05 SUBMITTALS/MATERIAL ACCEPTANCE – SIGN PANELS

A. Shop drawings: Fabrication shop drawings showing full size sign layout, color, message (including "City of Chicago" logo and date of sign fabrication), graphics and proposed materials for each sign assembly, including poles, bases and hardware must be submitted for approval prior to start of fabrication. Similar sign types that have the same sizes, colors, symbols and text layout must be submitted using one full size sign layout. Note: The message "City of Chicago XX", where XX represents the last two digits of the calendar year of sign manufacture, must be screened on all signs furnished under this contract. For stock items, submit manufacture's catalog sheets for approval before shipping the order.

B. Materials:

1. Aluminum: Mill Certifications, Samples
2. Powder coating: Test Data; Sample; Manufacturer's Certification that material complies with the required specifications.
3. Sign Face Material: Test Data; Samples; Manufacturer's Certification that material complies with the required specifications. Test Data must be gathered by an independent agency, such as AASHTO's National Transportation Product Evaluation Program (NTPEP). Test data must cover retroreflective sheeting and process inks and/or overlay films manufactured by the sheeting manufacturer in standard traffic colors.

C. Samples: Submit one sample for each sign type.

D. Certifications: The manufacturer must submit written certification for material's compliance with these specifications.

E. Maintenance Instructions: Submit manufacturer's printed instructions for maintenance of each product, coating and film, including precautions for use of cleaning materials and solvents for paint removal which could damage specified materials.

F. Warranty:

1. Non-Reflective Signs: The manufacturer's warranty period is five (5) years. Failures under warranty include, but are not limited to: coating degradation or failure, chalking, fading, structural or material failure, delamination of applied graphics and adhesive failure. The final punch list completion and acceptance constitutes the start of the warranty period.
2. Reflective Signs: The manufacturer's warranty period will be for seven (7) years. The warranty will cover the cost of replacement signs. Failure under warranty includes, but is not limited to: loss of retroreflectivity below the minimum specified under sign face materials above, deterioration of retroreflectivity sheeting to the extent that the sign is ineffective for its intended purpose when viewed from a moving vehicle under normal day and night driving conditions, coating degradation or failure, chalking, fading, structural or material failure, delamination of applied graphics and adhesive failure.

G. The final punch list completion and acceptance date constitutes the start of the warranty period.

2.06 SUBMITTALS/MATERIAL ACCEPTANCE – SIGN POLES

A. Shop Drawings: Fabrication shop drawings showing the full size layout, color, and proposed materials for poles, bases, and hardware must be submitted for approval prior to start of fabrication.

B. Poles: Mill certification, samples of each size of finished pole and extension.

C. Locking wedge and sleeve: Samples of each item.

D. Cast aluminum base: Mill Certifications.

E. Powder coating: Test Data; Sample; Manufacturer's Certification that material complies with the required specifications.

F. Galvanizing: Manufacturer's Certification for compliance with these specifications.

G. Stainless steel bolts and nuts, anchor bolts: sample, product data sheet.

H. Installation: All installation shall be performed in accordance with Article 720.04 of the Standard Specifications.

1. Dig Method: To install a sign pole by dig method, the Contractor will first drive a base sleeve to a level with the top of the sleeve near flush to the ground. The sign pole will then be inserted into the sleeve and raised to a level with the bottom of the pole 10 to 12 inches below the ground. The sign pole will then be locked in place by driving a locking wedge between the sign pole and the base sleeve. Note: Pipe sleeve and wedge shall not be bolted together. The holes at the top of the sign pole will be properly aligned such that the sign to be installed will properly face the flow of traffic.
2. Drill Method: The base will be secured to the concrete surface by steel expansion anchors and must be leveled by using stainless steel washers as shims at the anchor bolt locations and under the base castings. The sign pole will be installed into the cast iron base and locked in place with a carriage bolt with two flat washers and a nylon lock nut as shown in the Appendix I. The holes at the top of the sign pole must be aligned such that the sign to be installed will properly face the flow of traffic. Sign poles will be installed 18" from back of curb unless otherwise specified. Poles for transportation stops, e.g. bus, taxi, tour bus, or tour boat stops, must be installed 24" from the back of the curb unless otherwise noted.

I. Warranty: Manufacturer's warranties shall be 5 (five) years. The final punch list completion and acceptance date constitutes the start of the warranty period.

2.07 SUBMITTALS/MATERIAL ACCEPTANCE – SIGN POLES

A. Submit materials data, catalog sheets, certifications and samples, for each type of hardware specified, for the City's approval prior to the start of work.

B. Installation: All signs must be installed at locations and with mounting type as specified on Contract Drawings. Sign panels must be installed according to Article 720.04 of the Standard Specifications and as specified herein. Sketches showing 30° and 90° mounting details of signs are provided in the Appendix I. Sign panels will be installed on newly supplied sign poles and on existing light poles or traffic signal poles. Installation will include provision of all necessary support brackets, flanges, banding material, and hardware to provide a complete installation. On light poles or traffic signal poles, sign panels will be installed by the banding method. Guide signs and flag mounted signs will be installed on brackets banded to the light/signal pole. Two (2) stainless steel bands will be required for signs up to six (6) feet high. Three (3) bands will be required for signs over six (6) feet high.

C. Warranty: Manufacturer's warranty shall be 5 (five) years. The final punch list and acceptance date constitutes the start of the warranty period.

PART 3 - EXECUTION (see PART 2 above)

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. The Work of ROADWAY SIGNING will not be measured for payment.

4.02 PAYMENT

A. No separate payment will be made for the work covered in this section. Payment for the Work of ROADWAY SIGNING will be included in the contract lump sum price as shown in the Schedule of Prices for CIVIL WORK.

4.03 PAY ITEM ACCOUNT NUMBER

A. Civil Work: 020000.

END OF SECTION 34 71 24

APPENDIX A

CDOT DIVISION OF ELECTRICAL OPERATIONS

MATERIAL SPECIFICATIONS

APPENDIX A

CITY OF CHICAGO
DEPARTMENT OF TRANSPORTATION
DIVISION OF ELECTRICAL OPERATIONS

SUMMARY

This Appendix includes copies of technical documents which are made available to the Contractor as a convenience for informational purposes.

Document ***Pages***

SPECIFICATION NO. 1351, WIRE: SINGLE CONDUCTOR NO. 12 COPPER WITH CROSS LINKED POLYETHYLENE INSULATION
Dated June 7, 2006 4

SPECIFICATION NO. 1375, BASE: BALLAST HOUSING, NO. 7 U.S. STANDARD GAUGE STEEL
Dated March 31, 1977 3

SPECIFICATION NO. 1385, PEDESTAL WITH BASE: ALUMINUM FOR TRAFFIC SIGNALS
Dated July 31, 2006 2

SPECIFICATION NO. 1407, POLE MOUNTED CAST ALUMINUM JUNCTION BOX FOR TRAFFIC SIGNALS
Dated June 27, 2006 3

SPECIFICATION NO. 1428, THERMAL MAGNETIC CIRCUIT BREAKER
Dated September 11, 1989 4

SPECIFICATION NO. 1447, POLE: ANCHOR BASE, 3 AND 7 GAUGE, TAPERED TUBULAR STEEL, WITH HANDHOLE ENTRY
Dated March 20, 2007 10

SPECIFICATION NO. 1450, MAST ARMS: 4-, 8-, 12-, AND 15-FOOT: STEEL
Dated April 20, 2007 6

SPECIFICATION NO. 1457, CABLE: SERVICE ENTRANCE, THREE INSULATED CONDUCTORS IN ONE OVERALL JACKET, 600 VOLT
Dated August 3, 2006 6

SPECIFICATION NO. 1458, ELECTRICAL MANHOLE FRAMES AND COVERS 24 INCH AND 30 INCH DIAMETER
Dated July 10, 2006 2

CITY OF CHICAGO
DEPARTMENT OF TRANSPORTATION
DIVISION OF ELECTRICAL OPERATIONS

Document ***Pages***

SPECIFICATION NO. 1462, RIGID STEEL CONDUIT (HOT DIPPED GALVANIZED)
Dated August 3, 2006 7

SPECIFICATION NO. 1464, FUSES FOR STREET LIGHTING
Dated November 24, 1992 1

SPECIFICATION NO. 1465, GROUND RODS
Dated July 12, 2006 2

SPECIFICATION NO. 1467, ROD: ANCHOR, STEEL, WITH HARDWARE
Dated May 12, 1993 2

SPECIFICATION NO. 1474, CABLE: TRAFFIC SIGNAL CABLE MULTIPLE CONDUCTOR, COPPER WIRE, 600 VOLT CROSS-LINKED POLYETHYLENE INSULATION LOW SMOKE ZERO HALOGEN JACKET
Dated May 26, 2005 6

SPECIFICATION NO. 1475, CORD: TRAFFIC SIGNAL, EIGHT CONDUCTOR NO. 16 AWG, 600 VOLT
Dated September 26, 2006 5

SPECIFICATION NO. 1487, POLE: ORNAMENTAL, LOOP STYLE, 10 FOOT 15" BOLT CIRCLE; STEEL 7 GAUGE
Dated October 31, 1997 6

SPECIFICATION NO. 1488, PEDESTAL BASE: ORNAMENTAL, FOR 10 FOOT LOOP STYLE POLE
Dated July 15, 2002 8

SPECIFICATION NO. 1489, MAST ARM: ORNAMENTAL, FOR LOOP STYLE POLE, FOR MOUNTING TWO ACORN LUMINAIRES, ALUMINUM
Dated June 9, 1997 6

SPECIFICATION NO. 1493, TRAFFIC SIGNAL: VEHICULAR, TWELVE-INCH SINGLE FACE, SINGLE OR MULTIPLE-SECTION, POLYCARBONATE, LED OR INCANDESCENT
Dated March 20, 2000 8

SPECIFICATION NO. 1495, TRAFFIC SIGNAL MOUNTING BRACKET POLYCARBONATE, SIDE OF POLE
Dated March 20, 2000 3

CITY OF CHICAGO
DEPARTMENT OF TRANSPORTATION
DIVISION OF ELECTRICAL OPERATIONS

Document ***Pages***

SPECIFICATION NO. 1528, PRECAST CONCRETE STRUCTURES
Dated May 1, 2004 3

SPECIFICATION NO. 1533, NON-METALLIC CONDUIT
Dated August 8, 2006 2

SPECIFICATION NO. 1534, CABLE: SINGLE-CONDUCTOR, COPPER 600 VOLT
Dated September 25, 2006 6

SPECIFICATION NO. 1545, PEDESTRIAN COUNTDOWN TRAFFIC SIGNAL LED, 16 INCH WITH SYMBOLIC WALK/DON'T WALK LENSES
Dated January 28, 2010 7

SPECIFICATION NO. 1560, ADVANCED TRANSPORTATION CONTROLLER AND CABINET WITH UNINTERRUPTIBLE POWER SUPPLY
Dated June 1, 2009 42

SPECIFICATION NO. 1584, LUMINAIRE: COBRA-HEAD, ARTERIAL, LED (400 WATT LAMP HPS EQUIVALENT), IES CUTOFF TYPE II/III DISTRIBUTION
Dated January 14, 2014 9

SPECIFICATION NO. 1586, LUMINAIRE: LED, ORNAMENTAL, ARTERIAL ACORN I.E.S. TYPE II/III DISTRIBUTION
Dated October 28, 2014 10

SPECIFICATION NO. 1587, LUMINAIRE: LED, VIADUCT
Dated May 14, 2015 8

SPECIFICATION NO. 1595, LUMINAIRE: LED, COBRA-HEAD, ALLEY, IES CUTOFF TYPE I/II DISTRIBUTION
Dated May 14, 2015 9

SPECIFICATION NO. 1600, OUTDOOR LED LUMINAIRE SPECIFICATIONS: RESIDENTIAL STREETS, ALLEYS, & ARTERIAL STREETS (Cobra Head)
Dated December 9, 2016 19

SPECIFICATION NO. 1604, LUMINAIRE: LED, VIADUCT/ELEVATED STRUCTURE RETROFIT)
Dated April 10, 2018 12

SPECIFICATION NO. 1608, CONTROL: SMART LIGHTING, FOR ROADWAY LIGHTING, INTERNAL AND TWIST LOCK TYPE
Dated October 11, 2017 5

SPECIFICATION NO. 1612, OUTDOOR LED LUMINAIRE SPECIFICATION: ORNAMENTAL ARTERIAL STREETS (Acorn)
Dated December 7, 2017 11

SPECIFICATION NO. 1613, OUTDOOR LED LUMINAIRE SPECIFICATIONS: RESIDENTIAL STREETS, ALLEYS, & ARTERIAL STREETS (Cobra Head)
Dated July 18, 2018….. 17

ELECTRICAL SPECIFICATION 1351
DIVISION OF ELECTRICAL OPERATIONS
DEPARTMENT OF TRANSPORTATION
CITY OF CHICAGO
REVISED JUNE 7, 2006

WIRE: SINGLE CONDUCTOR NO. 12 COPPER WITH CROSS LINKED POLYETHYLENE INSULATION

SUBJECT

1. This specification states the requirements for insulated wire intended for use as a conductor to connect street light luminaires to aerial distribution wires or underground distribution cables in a street lighting circuit. This wire is also known as pole wire.

GENERAL

2. (a) Specifications. The cable shall conform in detail to the requirements herein stated and to the referenced specifications of the American Society for Testing and Materials (ASTM), the National Electric Code (NEC), Underwriters Laboratories (UL), the Insulated Cable Engineers Association (ICEA), and the National Electrical Manufacturers Association (NEMA), in which the most recently published revisions will govern.

(b) Acceptance. Cable not conforming to this specification will not be accepted.

(c) Sample. If requested by the Chief Procurement Officer, a three (3) foot sample of the cable intended to be provided under this specification , shall be submitted to the Engineer of Electricity within fifteen (15) business days after receipt of the request.

(d) Warranty. The manufacturer shall warrant the cable to be first class material throughout. The manufacturer will be responsible for any cable failing during normal and proper use within one (1) year after the date of installation. The manufacturer will provide replacement of any failed cable segment, from the point of normal termination to the next point of normal termination. There will be no cost to the City.

CABLE

3. (a) Construction. The cable shall consist of a coated copper conductor concentrically encased in a moisture resistant thermosetting plastic of cross linked polyethylene. The cable shall be listed with UL as Type RHW-2 or Type USE-2, and shall meet the NEC's requirements for these types of cable up to 90º C in wet or dry locations.

(b) Sealing. Both ends of each length of cable must be thoroughly sealed to prevent the entrance of moisture and other foreign matter.

(c) Color. All cables must use a carbon black pigmented cross linked polyethylene compound. Any other color must be an approved, permanent type coating applied to the carbon black insulation.

(d) Marking. The cable must be identified by a permanently inscribed legend in white lettering. The legend must have the following information at a minimum: 1/C #12AWG, 600V, XLPE, 90º, RHW-2 orUSE-2, manufacturer's name, date of manufacture. The legend must be repeated at approximately eighteen inch (18") intervals parallel to the longitudinal axis of the cable.

CONDUCTOR

4. (a) Material. Conductor shall be Number 12 AWG consisting of seven (7) strands of coated, annealed, copper wires (.0305 inch diameter) per ASTM-8, Class B.
(b) Resistivity. Conductor shall conform to the requirements of ASTM B-33.
(c) Coating. Conductor shall be tin coated in accordance with ASTM B-33.

INSULATION

5. (a) Type. The insulation shall be a cross linked polyethylene compound meeting the physical and electrical requirements herein specified and the requirements of NEMA WC-70 (ICEA S-95-658).

(b) Thickness. The insulation must be circular in cross section and have an average thickness of 45 mils. The thickness must not vary by more than

plus or minus five percent (+/-5%).

(c) Physical Properties

Initial Values:

Tensile strength, minimum psi	2000
Elongation at rupture, minimum %	250

TESTS

6. (a) General. The tests required to determine compliance with this specification must be certified by the manufacturer or an independent testing facility. Before shipment, copies of the test reports must be forwarded to the Division of Engineering for approval. The City reserves the right to reject any cable failing to meet the requirements of the tests. Tests must be made in accordance with methods in ASTM D-470.

(b) Physical Properties

After Aging:

1. After 168 hours in oxygen bomb at a pressure of 80 psi and a temperature at 127º +/-1º C :

Tensile strength, minimum % of initial value	75
Elongation at rupture, minimum % of initial value	75

2. After 168 hours in an air oven at 121º +/-1ºC :

Tensile strength, minimum % of initial value	80
Elongation at rupture, minimum % of initial value	80

(c) Modulus Test. After initial conditioning period of four (4) minutes at a temperature of 150º C and at 100% elongation, the modulus must not be less than 110 pounds per square inch.

(d) Accelerated Water Absorption Characteristics.

1. Electrical Method. After twenty-four (24) hours immersion in tap water at 75º +/- 1º C, the specific inductive capacity of the insulation must not be more than 7. After a continued fourteen (14) day immersion, the specific inductive capacity must not be more than three percent (3%) higher than the value determined at the end of the first day, nor more than two percent (2%) higher than the value determined at the end of the seventh day.

2. Gravimetric Method. The insulation must not absorb more than five (5) milligrams of water per square inch of exposed surface area after immersion in distilled water at 70º C for a period of seven (7) days.

(e) Electrical Characteristics. Each completed length of insulated conductor must withstand a test voltage of 3000 volts AC for a period of five (5) minutes after immersion in water for not less than six (6) hours and while still immersed. After withstanding this dielectric test, the cable must have an insulation resistance constant of not less than 25,000.

(f) Cold Bend Test. The cable must pass the cold bend, long-time voltage test on short specimens as outlined in ASTM D-470.

(g) Reports Required. Test reports must include the physical properties, both initial and after aging, the accelerated water absorption characteristics, and the electrical characteristics.

PACKING

7. The cable must be delivered in coils containing five hundred (500) feet each. Each coil must be packed in individual dispenser cartons. Each carton must be labeled, identifying the cable type and size, manufacturer, and date of manufacture.

SPECIFICATION 1375
BUREAU OF ELECTRICITY
DEPARTMENT OF STREETS
AND SANITATION
CITY OF CHICAGO
MARCH 31, 1977

BASE: BALLAST HOUSING, NO. 7 U.S. STANDARD GAUGE STEEL

SUBJECT

1. This specification states the requirements for ballast housing base assemblies to be installed on concrete foundations and to serve as bases for anchor base type steel poles with mast arm attached street light luminaires.

GENERAL REQUIREMENTS

2. (a) Specifications. The base assemblies must conform in detail to the requirements herein stated and to the specifications of the American Society for Testing and Materials, of which the latest published revisions will govern.

(b) Acceptance. Base assemblies not conforming to this specification will not be accepted.

(c) Drawings. The drawing mentioned herein is a drawing of the Department of Streets and Sanitation. It is an integral part of this specification cooperating to state necessary requirements.

(d) Shop Drawing. One complete set of shop drawings of the base assembly intended to be furnished must be submitted within fifteen (15) days upon request of the Chief Procurement Officer.

(e) Sample. One completely assembled base of the manufacture intended to be furnished must be submitted upon request of the Chief Procurement Officer within fifteen (15) days after receipt of the request.

DETAIL REQUIREMENTS

3. (a) Drawing. The base assembly must conform in detail to the design and dimensions shown on Drawing No. 785, dated March 25, 1977.

(b) Material. The steel used in the fabrication of the base assemblies must conform to ASTM A-606 Type 4 for the sides and door and to ASTM A-36 for the top, bottom and anchor plates.

(c) Thickness. The sides and door must be No. 7 U.S. Standard Gauge; the top, bottom and Anchor Plates must be 3/4 inch plate.

(d) Door. The door must be drilled top and bottom for, and furnished with, four (4) 1/4-20NCX3/4" button head stainless steel tamper resistant bolts for fastening top and bottom of door to base as shown on drawing No. 785. Ten (10) wrenches or drivers to fit the door bolts must be furnished with each fifty (50) base housings.

(e) Hardware. The bolts, nuts, lock washers and anchor plates must conform to drawing. Four (4) galvanized hex head machine bolts, four (4) galvanized hex nuts, four (4) galvanized lock washers, and two (2) 3/4" thick steel anchor plates must be furnished with each base assembly. The anchor plates must be shipped bolted to the top of the ballast housing assembly using the hardware enumerated above.

(f) Welding. Every welded joint must be made in conformity with the proper interpretation of the standard welding symbols of the American Welding Society as indicated on the drawings. Each bidder must submit with his proposal a drawing showing the sizes and types of welds, the type of electrode and the welding methods he proposes to use in fabricating the base assembly.

(g) Sandblasting. The door and ballast housing must be thoroughly sand blasted to remove all scale, oil or slag prior to painting.

(h) Dating. The top of the ballast housing base must be stamped or engraved with the year of manufacture in numerals not less than 1/2" in height.

(i) Painting. A coat of Penetrol must be applied on the inside weld of the base. The complete base assembly, inside and outside, is to be given a coat of iron oxide zinc chromate primer meeting the requirements of Federal Specification TT-P-636B.

TESTING

4. (a) Chemical Composition. Certified reports from the steel manufacturer must be furnished to the city upon request of the Purchasing Agent.

(b) Test Specimens. Must conform to the requirements of ASTM Specifications A-36 and A-606 Type 4.

(c) Strength Tests. One test specimen of the metal in each order of 50 base assemblies or less must be tested for tensile strength and elongation, in accordance with ASTM Standards.

(d) Welding Tests. One percent (1%) of the longitudinal and circumferential welds of the base assembly must be inspected for penetration and soundness of the welds by the magnetic particle inspection method or by radiography. If the magnetic inspection process is used, the dry method with direct current must be employed. All transverse welds must be magnetized by the "prod" (circular magnetization) method. Longitudinal welds may be magnetized by either circular or longitudinal magnetization.

(e) Certificate. One certified copy of the test data sheet must be furnished to the City before delivery of the bases.

PACKING

5. When packed for transportation and delivery as per paragraph 3(e), the base assemblies must be thoroughly blocked or otherwise protected to prevent damage to painted surfaces.

INSPECTION

6. An inspector representing the City must have free entry at all times, while the work on the contract is being performed, to all parts of the manufacture of these base assemblies. The manufacturer must afford the inspector, without charge, all reasonable facilities to satisfy him that the base assemblies are being furnished in accord with this specification. The final inspection must be made at the facilities of the manufacturer.

THIS SPECIFICATION MUST NOT BE ALTERED

SPECIFICATION 1385
DEPARTMENT OF STREETS AND SANITATION
BUREAU OF ELECTRICITY
CITY OF CHICAGO
REVISED JULY 31, 2006

PEDESTAL WITH BASE: ALUMINUM, FOR TRAFFIC SIGNALS

SUBJECT

1. The specification states the requirements of an aluminum pedestal and base with handhole and door for supporting a traffic signal.

GENERAL

2. (a) Specifications. The pedestal base must conform to the requirements herein stated, to the specifications and methods of test of the American Society for Testing and Materials cited by ASTM Designation Number, of which the most recently published revisions will govern, and to the requirements of the American Welding Society.

(b) Acceptance. Pedestal bases not conforming to this specification will not be accepted.

(c) Drawing. The drawing mentioned herein is a drawing of the Department of Streets and Sanitation. It is an integral part of this specification cooperating to state the necessary requirements.

(d) Workmanship. All pedestal bases must be free of casting flaws and must have neat, smooth exterior surfaces. All holes must be accurately located and drilled. The bottom surface of the base must be ground smooth.

(e) Sample. One complete pedestal of the manufacture intended to be furnished must be submitted within fifteen (15) days upon receipt of a request from the Chief Procurement Officer.

DETAIL REQUIREMENTS

3. (a) Design. The pedestal base must conform to the design shown on Drawing Number 526. All bases must be of the same dimensions, and all doors must be interchangeable.

(b) Base. The base must be cast of aluminum alloy 319 of ASTM B26 with a minimum wall 9/32 inch thick. The handhole opening must have a recessed lip along the entire length of both sides and the bottom such that with the door in place the exterior surface of the door is flush with the exterior surface of the base. The door must have the same curvature as the base. The door must be locked in place by means of two fingers located on its top edge which bear against the inside surface of the base, and a stainless steel Allen head locking screw which fastens to the base. The locking screw must be protected by a C-shaped drip edge protruding approximately 5/8" and concentrically encircling the screw head. The clearance between the inner surface of the drip edge and the outer surface of the screw head must be no greater than 1/8". The drip edge must encircle the screw head by a minimum of 300° with the opening in the drip edge centered at the bottom of the screw head. A continuous pipe stop must be integrally cast along the inside of the base 2.5" below the top edge.

(c) Pedestal. The pedestal must be aluminum-alloy extruded round tube conforming to the requirements of ASTM-B221, alloy 6063-T6. The aluminum pedestal must be flash anodized in accordance with Aluminum Association designation C22A21 or Alcoa designation 202-R1. Its outside diameter must be 5.563 inches; its wall must be not less than 0.187 inch thick, and its length must be as required to furnish the overall height specified in the order. The round tube must be inserted not less than two and one-half (2.5) inches into the base and welded with four (4) butt welds each not less than one (1) inch long on the inside and a continuous seam weld around the outside. Aluminum alloy pipe in lieu of aluminum alloy tube is acceptable.

(d) Welding. The welds must be made by the inert gas metal welding process. Filler wire must conform to chemical composition requirements of American Welding Society Alloy Number A5.10-69.

(e) Packing. The pedestal base must be suitably packed or blocked to prevent damage during shipment and handling.

THIS SPECIFICATION MUST NOT BE ALTERED

SPECIFICATION 1407
BUREAU OF ELECTRICITY
DEPARTMENT OF STREETS
AND SANITATION
CITY OF CHICAGO
REVISED JUNE 27, 2006

POLE MOUNTED CAST ALUMINUM JUNCTION BOX FOR TRAFFIC SIGNALS

SCOPE

1. This specification states the requirements for pole mounted, cast aluminum junction boxes to be used as enclosures for traffic signal multiple cable terminals.

GENERAL

2. (a) Specifications. The junction boxes must conform in detail to the requirements herein stated, and to the specifications and methods of test of the American Society for Testing and Materials cited by ASTM Designation Number, of which the most recently published revisions will govern.

(b) Drawing. The drawing mentioned herein is a drawing of the Department of Streets and Sanitation, Bureau of Electricity, and will be interpreted as part of these specifications.

(c) Acceptance. Junction boxes not conforming to this specification will not be accepted.

(d) Sample. One complete junction box of the manufacture intended to be furnished must be submitted within fifteen (15) business days after receipt of a request from the Chief Procurement Officer. The box must be delivered to the Bureau of Electricity.

(e) Workmanship. All junction boxes must be free of casting flaws and must have neat, smooth exterior surfaces. All holes must be accurately located and drilled to ensure interchangeability of all components.

DESIGN

3. (a) Drawing. The junction box must conform in detail to the dimensions and requirements shown on drawing number 954.

(b) Material. The body door and plate must be castings of non-heat treated

aluminum silicon alloy conforming to ANSI alloy 443.0 of ASTM B26.

DETAIL REQUIREMENTS

4. (a) Assembly. Each junction box must consist of the body, door with its gasket, flat plate with its gasket, terminal block mounting bracket and bottom gasket with its stainless steel hardware furnished as described below, all completely assembled, painted and ready for installation.

(b) Body. The body must be cast as shown in drawing number 954. The top and bottom sides of the box where flat plates, or other fittings, will be attached, must be identically cast, machined flat, and drilled and tapped in accordance with dimensions shown. All fittings which fit on the top side must fit on the bottom side.

(c) Door. The door must be cast as shown in drawing number 954. The door must be hinged at the left with stainless steel hinge pins and must open not less than 180º to permit complete access to the interior of the junction box. Two stainless steel Allen head machine screws, undercut and held captive, must hold the door closed and maintain positive pressure against a sponge neoprene gasket cemented in place completely around the door jamb. The door must be finished and painted prior to cementing the gasket into its groove in the door.

(d) End Plate. A flat end plate must be furnished with each body casting. The plate must be drilled to align with tapped holes in the body casting and have a flush match with the periphery of the top and bottom body casting pads. The plate must have a properly fitted gasket and be held in place by four (4) stainless steel machine screws.

(e) Mounting Bracket. A terminal block mounting bracket, as shown on Drawing Number 954, must be furnished and installed in each junction box. The bracket must be cast from ANSI alloy 443.0 per ASTM B26.

(f) Gaskets. The gasketing between the body and the door must be of sponge neoprene and must be cemented in place after painting of the door. A cork gasket, 1/8 inch thick, must be used between the end plate and the body of the junction box on the top end and held in place by four (4) stainless steel screws. An identical cork gasket and four (4) stainless steel screws must be placed within the box before shipping. This gasket with its screws will be used with the fitting used on the bottom end of the box.

(g) Hardware. The hinge pins and all screws required for assembly of this junction box must be of stainless steel.

(h) Painting. The exterior surfaces of the junction box must be properly cleaned

and given one (1) coat of zinc chromate primer containing ten percent (10%) iron oxide and one (1) coat of enamel. The color of the enamel must be gloss black or as ordered. A color sample must be submitted and approved before manufacturing commences. The primer and enamel must be of an approved grade and quality.

(i) Packing. After the paint is completely dry, and the junction boxes have been assembled, they must be suitably packed to prevent damage to painted surfaces during shipping and handling. All shipments must be fastened to, and shipped on, 48" x 48" hardwood, 4 way, non-returnable pallets. Total height must not exceed 64" and total weight must not exceed 2,000 pounds.

INSPECTION

5. An inspector representing the City of Chicago must have free access, at all times while work on these junction boxes is being performed, to all parts of the manufacturer's work which are concerned with their manufacture. The manufacturer must afford the inspector, without charge, all reasonable facilities to satisfy him that the junction boxes are being furnished in accordance with this specification. The final inspection must be made at the point of delivery. Any junction boxes rejected must be removed and disposed of by the Contractor at his sole expense.

SPECIFICATION 1428
BUREAU OF ELECTRICITY
DEPARTMENT OF STREETS
AND SANITATION CITY OF
CHICAGO
SEPTEMBER 11, 1989

THERMAL MAGNETIC CIRCUIT BREAKER

SUBJECT

1. This specification covers the requirements for thermal-magnetic circuit breakers capable of providing complete over-current protection for street lighting branch-load and service circuits.

GENERAL REQUIREMENTS

2. (a) Sample. One complete circuit breaker of each type and size, and of the manufacture intended to be furnished must be submitted upon request of the Chief Procurement Officer within fifteen (15) business days after receipt of such request. The sample(s) must be delivered to the Engineer of Electricity, Bureau of Electricity, 2451 South Ashland Avenue, Chicago, Illinois 60608.

(b) U.L. Approval. Circuit breakers furnished under this specification must be listed and approved by Underwriter's Laboratories, Inc.

(c) Applicable Specifications. Where reference is made to applicable requirements of Underwriter's Laboratories, Inc., Bulletin #489, entitled "Standard for Branch Circuit and Service Circuit Breakers," hereinafter cited as the U.L. Standards, the most recently published revision will govern.

(d) Assembly. Each circuit breaker must have the thermal-magnetic trip installed, calibrated and sealed within its insulated housing.

(e) Instructions. Complete installation instructions, details on wiring, and information on operation must be furnished with each circuit breaker, except as otherwise indicated.

(f) Packing. Each circuit breaker must be packed in a suitable manner so that it will not be damaged in shipping or handling.

TYPES AND SIZES

3. (a) EHD Frame Circuit Breakers. For use on A-C Systems with a 100-ampere frame; minimum interrupting rating of 18,000 R.M.S. symmetrical amperes at 240 volts A.C.

1. Single pole, 240 or 480 volts A.C., ampere rating from 15 to 100.

Double pole, 240 or 480 volts A.C., ampere rating from 15 to 100.

(b) FDB Frame Circuit Breakers. For use on A-C Systems with a 150 ampere frame; minimum interrupting capacity of 18,000 R.M.S. symmetrical amperes at 240 volts A-C.

1. Double pole, 240, 480 or 600 volts A-C, ampere rating from 15 to 150.

2. Triple pole, 240, 480 or 600 volts A-C, ampere rating from 15 to 150.

(c) JDB Frame Circuit Breakers. For use on A-C Systems with a 250 ampere frame; minimum interrupting current of 65,000 R.M.S. symmetrical amperes at 240 volts A-C.

1. Double pole, 240, 480 or 600 volts A-C, ampere ratings from 70 to 250.

2. Triple pole, 240, 480 or 600 volts A-C, ampere ratings from 70 to 250.

DESIGN AND CONSTRUCTION

4. Circuit breakers furnished under this specification must include the following design and construction features: (1) molded insulated housing, (2) thermal-magnetic trip mechanism, (3) silver alloy contacts, (4) corrosion-resistant internal parts, (5) trip-free, indicating handle, and (6) pressure-type terminals.

DETAIL REQUIREMENTS

5. (a) Thermal-Magnetic Trip Mechanism. The breaker must be activated on current overload by means of a thermal-magnetic trip mechanism. This mechanism must be non-adjustable, non-interchangeable, and factory calibrated and sealed. Instantaneous tripping as controlled by the magnetic trip setting, and time delay tripping accomplished by thermal action must be in accordance with the manufacturer's published characteristic curves for these breakers or with calibration requirements of the U. L. Standards, as applicable.

(b) Contact Mechanism. The contacts must be spring loaded and provide a quick-make, quick-break non-teasing action. The contact mechanism must be such that the breaker will trip open even if the handle is held or locked in the ON position.

(c) Calibration. Rating and performance of these breakers must be based on calibration at an ambient temperature of 40° C. (104°F.).

(d) Rated Current. Each breaker must be capable of carrying 100% rated current continuously in its calibrated ambient temperature without tripping and without exceeding the temperature limits specified in the U. L. Standards.

(e) Contacts. The contacts must be made of a non-welding silver alloy or equivalent, subject to approval.

(f) Internal Parts. All internal parts of these circuit breakers must be corrosion resistant material.

(g) Terminals. Solderless, pressure type terminals of copper construction must be provided for both line and load connections.

(h) Handle Indication. The handle must indicate clearly whether the circuit breaker is on the ON, OFF, or TRIPPED position.

(i) Mounting. Breakers furnished under this specification must have drilled and counterbored holes for front mounting which must conform to spacings shown on Department of Streets and Sanitation Drawings numbered 883, 884, 886, and 887.

(j) Test Requirements. These breakers must be capable of meeting the following sequence of test requirements as specified in the U. L. Standards.

1. Endurance test.

2. Calibration test at 200% and 125% of rated current.

3. Short circuit tests

4. Calibration test at 500% rated current.

5. Dielectric strength test.

WARRANTY

6. Circuit breakers furnished under this specification must be warranted by the manufacturer against defects in materials or workmanship for a period of one year after installation. During this period, should a failure occur, repair or replacement must be made without cost to the City.

THIS SPECIFICATION MUST NOT BE ALTERED

SPECIFICATION 1447
BUREAU OF ELECTRICITY
DEPARTMENT OF STREETS
AND SANITATION
CITY OF CHICAGO
REVISED MARCH 20, 2007

POLE: ANCHOR BASE, 3 AND 7 GAUGE, TAPERED TUBULAR STEEL, WITH HANDHOLE ENTRY

SUBJECT

1. This specification states the requirements for tapered, tubular, 3 gauge and 7 gauge steel anchor base poles with mast arm supports. They will support street light luminaires and/or traffic signal mast arms and will be served by underground cables.

GENERAL

2. (a) Specifications. The poles must conform in detail to the requirements herein stated, and to the Specifications and Methods of Test of the American Society for Testing and Materials cited by ASTM Designation Number of which the most recently published revisions will govern.

(b) Acceptance. Poles not conforming to this specification will not be accepted.

(c) Bidders Drawings. Bidders must submit with their bids detailed scale drawings of the mast showing actual dimensions, details, and welds. Shop drawings must be original engineering drawings created by the manufacturer. The drawings must show every dimension necessary to show how all parts will fit each other and be properly held in assembly. These drawings must also be submitted in electronic format, preferably Microstation 95, if so requested by the City.

(d) Drawings. The drawings mentioned herein are drawings of the Department of Streets and Sanitation being an integral part of this specification cooperating to state necessary requirements.

(e) Sample. If requested by the Chief Procurement Officer, one completely assembled anchor-base pole of the manufacture intended to be furnished, must be submitted for review within fifteen (15) business days of receiving the request.

(f) Warranty. The manufacturer must warrant the performance and construction

of the light poles to meet the requirements of this Specification and must warrant all parts, components, and appurtenances against defects due to design, workmanship, or material developing within a period of five years after the light poles have been delivered. This will be interpreted particularly to mean structural or mechanical failure of any element or weld, or failure of any portion of the painting system. The warranty must be furnished in writing guaranteeing material replacement including shipment, free of charge to the City. The Commissioner will be the sole judge in determining which replacements are to be made and the Commissioner's decision will be final.

STANDARDS

3. (a) Assembly. Each anchor base pole must consist of a steel mast with handhole entry, entry door with machine screws, grounding nut, mast base plate, top cap for mast, two (2) mast arm supports, bolt covers, and all necessary hardware required for complete assembly of these parts, ready for assembly, without special tools.

(b) Interchangeability. Members of each pole type must be mutually interchangeable for assembly, so that no reworking will be required to make any member fit properly in the place of any other similar member of any other similar pole.

(c) Design. Each pole type must conform in design and dimensions to the pertinent drawing(s) listed in Table "A".

MASTS

4. (a) Mast Size. The outside diameters of the mast of each pole type must be as listed in Table A. The mast must be tapered at 0.14 inches per foot.

(b) Material. The mast must be fabricated from one length of No. 3, No. 7, or No. 11 Standard gauge steel meeting the material requirements of ASTM A606 for low alloy high strength coil steel, which, after fabrication, must possess an ultimate tensile strength of not less than 70,000 psi and a yield strength of not less than 60,000 psi, in accordance with ASTM A595, Grade C. Chemistry of the steel must be such as to insure resistance to atmospheric corrosion superior to that of ordinary copper bearing steel. Material certification is required. Manufacturer's steel meeting the specified physical and chemical requirements, and approved by the Commissioner, will be accepted.

(c) Fabrication. The mast must be fabricated with not more than one (1) longitudinal weld. The weld must be ground smooth so that it is virtually invisible. There must be no lateral welds in the masts other than where the masts are welded to the steel bases. Each mast must be straight and centered

on its longitudinal axis. Each mast must be formed on a mandrel and worked to form a round cross-section. The completed, unpainted masts must have smooth external surfaces free from protuberances, dents, cracks or other imperfections marring their appearance.

(d) Base. The mast base must be a steel plate, of low alloy, high strength steel as noted in Par. 4 (b).

Plate Base. The base plate for each pole type must be as listed in Table "A". It must be fabricated from the same ASTM A606 low alloy, high strength steel as is used for the mast. After fabrication the steel must meet the requirements of ASTM A588. The mast must be inserted into the base to a maximum depth which will still allow for an adequate weld to be made between the bottom of the mast and the plate. A circumferential weld must be made between the mast and the base at both the top and underside of the plate. Non-metallic removable bolt covers which completely cover the anchor bolts and nuts must be provided. The covers must be attached with stainless steel screws coated with a non-seizing compound, or another type of non-seizing fastener, as approved by the Commissioner. The covers must enclose the anchor bolts and be secured in an approved manner. The base must be attached to the mast so that the bearing surface of the base is at right angles to the longitudinal axis of the mast. The vertical center line of the seam must be positioned so that no welds for the simplex attachments or the handhole opening will go through the seam.

Anchor Rod Openings. All anchor rod openings for each pole type must have a width as listed in Table "A". Each opening must be sized to have a circumferential slot length equal to 15 degrees of the circumference.

(e) Mast Arm Support Plates. The mast arm support plates will be made of cast steel conforming to the requirements for Grade 65-35 cast steel of ASTM A27, or equivalent, subject to approval. They must neatly fit the external surface of the mast. The upper mast arm support plate must have a hollow protuberance, the hole of which must be approximately equivalent to two (2) inches in diameter, extending into the interior of the pole providing a smooth surface for the lamp cables to rest upon. The mast arm support plates must be designed so that they will carry the mast arm and hold it in the proper position for fastening the mast arm to the mast. The design of the mast arm support plates must be a two (2) bolt type as shown on Drawing No. 659.

(f) Provision for Ground. A 1/2-13 square nut must be welded to the inside of the mast on the handhole entry frame for a ground connection.

(g) Entry. A vertical doorframe carrying a removable door providing access to the interior of the mast must be welded into a close fitting opening centered approximately 15 inches above the bottom of the base. The doorframe must

be formed and welded of steel with a cross section of two and one-quarter(2-1/4) inches wide by one-quarter (1/4) inch thick so as to adequately reinforce the opening of the mast. The internal horizontal clearance of the doorframe must be four and three-quarter (4-3/4) inches; its internal vertical clearance must be seven (7) inches. Its upper and lower ends must be semi-circular meeting its straight sides tangentially. The radius of this opening must be two and three-eighths (2-3/8) inches. The vertical center line of the entry must be at a right angle clockwise from the vertical center line of the mast arm supports. The frame must have two welded tabs; one at the top and one at the bottom of the door frame. These tabs must be drilled and tapped to accept a 1/4-20 UNC screw. The top hole must be located 13/16 of an inch from the top of the opening. The bottom hole must be located 13/16 of an inch from the bottom of the opening. The 1/4-20 machine screws must be stainless steel with hex heads, meeting the requirements of ASTM A193. The screws must be treated with a compound to prevent seizing. Other non-seizing types of screws and fasteners may be considered. An alternate method of attachment consisting of a removable hinge on the bottom with a screw connection at the top may be considered. (The above requirements apply to all pole masts except those with a 10 inch bolt circle. Poles with 10 inch bolt circles must have handhole openings of 3" by 5". All other requirements apply.)

(h) Door. The removable door must be formed of sheet steel approximately one-eigth (1/8) inch thick. It must be flat or dished depending upon the pole type, and fit the doorframe closely so that it will stay in proper position even if its locking screws are slightly loosened. The door must be drilled top and bottom to accept the 1/4-20 hex head machine screws which will fasten the door to the doorframe. A half-circle piece of steel must be welded by the screw opening, to allow only a socket wrench to be used. All doors must be interchangeable. An alternate method of attachment using an internal hinge at the bottom of the door with a screw at the top of the door will be considered. Any alternate method will be subject to approval by the Commissioner or his duly authorized representative.

(i) Locking Device. Any other door locking device, other than the one outlined above in (g) and (h), must be approved by the Commissioner or his duly authorized representative.

(j) Tag. To each pole must be attached immediately below the handhole, by mechanical means and not by adhesive, a stainless steel tag with a stamped or embossed legend which must include the pole outside diameter at the base, the overall length, and the gauge; i.e., 12.5" X 34'-6" X 3 gauge.

(k) Structural Requirements. The mast must be manufactured in accordance with AASTHO's 1994 version of the "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals". The shaft and base assembly must be designed to meet AASTHO's 1994 criteria for 80

MPH wind loading with a 30% gust factor. The poles must be designed appropriately for Chicago applications for both street lighting and traffic signal applications, including signal mast arms.

TOP

5. (a) Design. The mast top must be essentially conical with a globe-shaped upper-end and having a minimum wall thickness throughout of not less than 1/4 inch. The cone portion must meet the skirted portion of the top in a smooth filet, the skirt must enclose the top 7/8" inches of the mast. Three stainless steel, or other similar approved material, set screws not less than 3/4 inches long must be equally spaced in tapped holes around the skirt and must hold the top securely in place atop the mast. The design of the top must be similar to one shown on Drawing #11420A.

(b) Material. The top must be aluminum alloy 356-F per ASTM B108. It must have smooth surfaces, neat edges and corners and be free from fins, holes or other casting flaws. Non-metallic tops may be substituted if approved by the Commissioner.

(c) Finish. Tops must be painted as herein specified.

HARDWARE

6. All the hardware necessary to complete the assembly of the pole must be furnished. All hardware will be as specified elsewhere in these specifications. Hardware not specified elsewhere must be stainless steel meeting the requirements of ASTM A193, or equal corrosion-resistant non-seizing metal, or a non-metallic material subject to approval by the Commissioner.

WELDING

7. (a) General. Every welded joint must be made in conformity with the proper interpretation of the standard welding symbols of the American Welding Society as indicated on the drawings; however, each bidder must submit with his proposal a drawing showing the sizes and types of welds, must state the type of electrode, and must describe the welding methods, he proposes to use in fabricating the pole.

(b) Testing. Welds must be inspected for penetration and soundness of the welds by the magnetic particle inspection method or by radiography. Acceptance or rejection will be governed by the same conditions as in Section 9. If the magnetic inspection process is to be used, the dry method with the direct current must be employed. All transverse welds must be magnetized by the "prod" (Circular magnetization) method. Longitudinal

welds may be magnetized by either circular or longitudinal magnetization.

PAINTING

8. (a) Oil and Grease Removal. All metal surfaces must be washed with an alkaline detergent to remove any oils or grease.

(b) Metal Cleaning. All exterior metal surfaces must be cleaned by blasting with a combination of shot and grit to remove all dirt, mill scale, rust, corrosion, oxides and foreign matter and provide a "near white" surface in accordance with SSPCS-SP10. Included in this process must be the interior base section of the mast to a minimum height of twelve (12) inches.

(c) Chemical Pretreatment. The cleaned metal surfaces must then be treated with a hot, pressurized iron phosphate wash and must be dried by convection heat.

(d) Primer Coat. All exterior surfaces are to be coated with Tnemec 90-97 corrosion-inhibiting zinc-rich aromatic urethane to a minimum dry film thickness of 2.5 mils (.0025”). The aromatic urethane is to consist of a zinc dust content not less than 83% by weight in dried film. The coating must be airless-spray applied and moisture cured.

(e) Finish Coat. All exterior surfaces are to be subsequently coated with Tnemec Endura-Shield II 1074 aliphatic acrylic polyurethane to a minimum dry film thickness of 3.0 mils (.003”). The coating must be airless-spray applied and cured in a gas-fired convection oven by heating the steel substrate to between 150° Fahrenheit and 220° Fahrenheit.

(f) Interior Coat. Interior surfaces are to be coated with red oxide rust inhibitive alkyd primer to a dry film thickness of 1.5 mils.

(g) Durability. Both the exterior and interior coats must be capable of passing 1,000 hours of salt spray exposure as per ASTM B117 in a five percent (5%) NaCl (by weight) solution at 95°F and 95% relative humidity without blistering Before test, the panel must be scribed with an "X" down to bare metal.

(h) Coating Measurement. Measurement of coating thickness must be done in accordance with SSPC-Pa 2-73T, "Measurement of Dry Paint Thickness with Magnetic Gauges," except that the lowest "single spot measurement" in an area of two square inches must be not less than 5.5 mils.

(i) Color. Color must be gloss black unless otherwise noted in the order. A color sample must be submitted for approval prior to fabrication.

(j) Alternate Methods. Alternate painting methods may be reviewed and tested on a case by case basis. However, no coating method will be accepted unless the Commissioner judges such alternate to be equal to the coating herein specified.

MAST TEST

9. (a) General. All completed masts must be available for testing for maximum deflection and set. The masts must meet the structural requirements of Section 4(k). Unless specifically authorized in writing, all tests must be made at the works of the manufacturer. The tests must be witnessed and certified by an engineer from the Bureau of Electricity. If an engineer from the Bureau is not available, an independent consultant, approved by the Bureau, must witness and certify the tests. There will be no cost to the City for this. A record of every test must be made and a certified copy of the test record must be submitted to the Commissioner before the masts are shipped.

(b) Lot. Tests for welds, deflection and set of the mast and of the mast arm supports must be made upon three (3) masts of the first fifty (50) in every order. An additional one (1) mast must be tested for each additional fifty (50) masts in the order. The selection of masts for testing must be random from the entire completed lot. If any of the masts in any lot fail to meet the test, an additional three (3) masts of the same lot must be tested. If any of these masts fail to meet the test requirements, the entire lot will be subject to rejection, except that the manufacturer may subject each mast in the lot to the test, and those which fulfill the requirement will be accepted. After testing, each base weld must be inspected by the magnetic particle method to determine that the welds have not been affected.

(c) Mast Requirements. With base rigidly anchored, a test load as indicated in Table A must be applied at a point approximately two feet (2'0") from the free end. The load must be applied at right angles to the center line of the mast and in the same vertical plane. The deflection must not be greater than that indicated in Table A. Within one (1) minute after the test load is released, measurement must be made of the set taken by the mast. This set must not be greater than that indicated in Table A. The deflection measurement device must be reset to zero and the test load must be reapplied. The deflection must not change from the deflection noted in the first test by more than $\pm$5%. No measurable set must be noted within one (1) minute after test load is released.

(d) Mast Arm Support (simplex) Requirements. With an appropriate mast arm firmly attached to the mast, a test load of 300 pounds must be applied to the mast arm as a side pull at a point seven (7) feet from the mast. After the test, the mast arm support welds on the mast must be tested by the magnetic

particle method to determine that they have not been affected.

(e) The contractor must include in his bid, the cost of travel, food and lodging for one (1) engineer. Travel for 150 miles or greater must utilize a major airline. Lodging accommodations must be equal to those provided at a Holiday Inn. The engineer must be given ten (10) working days notice of travel arrangements.

PACKAGING

10. (a) General. The poles must be shipped in twelve (12) pole bundles. Each pole must be individually wrapped so that the pole can be bundled for shipping and unbundled for delivery to the City without damaging the pole or its finish.

(b) Bundles. The bundles must consist of twelve (12) poles laid base to top to form an approximately rectangular cylinder. Materials such as lumber (2" x 4" min.), non-marring banding, and other appropriate bundling materials must be used to make a rigid, long lasting, bundle capable of being handled, shipped and stored without shifting of contents or breaking, subject to approval. Any bundles, in which either poles or packaging is received broken, damaged or with contents shifted, will not be accepted and it will be the responsibility of the supplier to return the bundle to its original destination at no cost to the City of Chicago. The bundles should be capable of being stacked two (2) high without breaking, or shifting of the contents. Each bundle must be capable of being lifted by a fork lift truck or crane and the bundles must be shipped on a flat bed truck to facilitate unloading. Each pole wrapping must be clearly labeled indicating the pole size, i.e. 34'6", 7 GAUGE, STEEL POLE, 15" B.C.

(c) Hardware. The bolt covers and their attachment devices must be shipped with each bundle and packaged in twelve (12) sets of four (4) each. The package must be labeled and placed in a prominent position to facilitate accessibility, and must be attached to, or within, the bundle in such a manner as to assure safe delivery. Payment will be withheld for any bundle delivered without the accompanying hardware. Pole caps must be attached at the manufacturer's facilities, or be packed separately in a manner similar to the bolt covers, and the same payment conditions will prevail. Cracked, broken or chipped parts will be considered as an incomplete delivery as regards payment.

(d) Delivery. All poles will be delivered to the Bureau of Electricity storage yard at 4101 South Cicero Avenue in Chicago, or to another location within the City as indicated on the order. Light pole information must include any recommendations of the manufacturer for storage.

INSPECTION

11. An inspector representing the City must have free entry at all times, while the work on the contract is being performed, to all parts of the manufacturer's works which concern the manufacture of poles. The manufacturer must afford the inspector, without charge, all reasonable facilities to satisfy him that the poles are being furnished in accord with these specifications. The final inspection must be made at point of delivery. Any poles rejected as defective must be removed and disposed of by the contractor at his sole cost.

TABLE A

POLE	GAUGE	BOLT CIRCLE	ANCHOR ROD	BASE PLATE	TEST LOAD	MAX. DEF	MAX. SET	DRAWING
7.67"x12.5" x34'6"	3	16.5"	1.5"	1.75"	3200#	22"	2.5"	827
6.17"x11"x 34'6"	3	17.25"	1.25"	1.5"	2500#	26"	2.5"	824
5.17"x10.0" x34'6"	3	15.0"	1.25"	1.5"	2000#	30"	2.5"	808
5.17"x10.0" x34'6"	7	15.0"	1.25"	1.5"	1500#	30"	2.5"	808
3.95"x8.5"x 32'6"	3	11.5"	1.25"	1.5"	1500#	33"	2.5"	763
3.95"x8.5"x 32'6"	7	11.5"	1.0"	1.25"	1200#	33"	2.5"	762
3.87"x8.0"x 29'6"	3	10.0"	1.0"	1.5"	1500#	28"	1.0"	657
3.87"x8.0"x 29'6"	7	10.0"	1.0"	1.25"	1200#	28"	1.0"	656
4.15"x8.0"x 27'6"	3	10.0"	1.0"	1.5"	1500#	23"	1.0"	655
4.15"x8.0"x 27'6"	7	10.0"	1.0"	1.25	1200#	23"	1.0"	654
4.20"x7.0"x 20'0"	3	10.0"	1.0"	1.0"	1500#	13"	1.0"	653
3.70"x6.5"x 20'0"	11	10.0"	1.0"	1.0"	800#	14"	1.0"	652

SPECIFICATION 1450
BUREAU OF ELECTRICITY
DEPARTMENT OF STREETS
AND SANITATION
CITY OF CHICAGO
REVISED APRIL 20, 2007

MAST ARMS: 4-, 8-, 12-, AND 15-FOOT: STEEL

SUBJECT

1. This specification covers the requirements for 4-, 8-, 12-, and 15-foot steel mast arms for supporting street light luminaires.

GENERAL

2. (a) Specifications. The mast arms must conform in detail to the requirements herein stated and to the Specifications and Methods of Test of the American Society for Testing and Materials cited by ASTM Designation Number of which the most recently published revision will govern.

(b) Acceptance. Mast arms not conforming to this specification will not be accepted.

(c) Drawings. The drawings mentioned herein are drawings of the Department of Streets and Sanitation. They are integral parts of this specification cooperating to state necessary requirements.

(d) Bidders Drawings. Bidders must submit with their bids detailed scale drawings of the mast arms and attachments showing actual dimensions, details, and welds. Shop drawings must be original engineering drawings created by the manufacturer. The drawings must give every dimension necessary to show how the parts will fit each other and be properly held in assembly. These drawings must be submitted in electronic format, preferably Microstation 95, if so requested by the City.

(e) Sample. One complete mast arm of each size and of the manufacture intended to be furnished must be submitted within fifteen (15) business days upon request of the Chief Procurement Officer.

(f) Warranty. The manufacturer must warrant the performance and construction of the mast arms to meet the requirements of this Specification and must warrant all parts, components, and appurtenances against defects due to design, workmanship, or material developing within a period of three years

after the mast arms have been delivered. This will be interpreted particularly to mean structural or mechanical failure of any element or weld, or failure of any portion of the painting system. The warranty must be furnished in writing guaranteeing material replacement including shipment, free of charge to the City. The Commissioner will be the sole judge in determining which replacements are to be made and the Commissioner's decision will be final.

DESIGN

3. (a) 4-Foot Mast Arm. Each 4-foot mast arm must be fabricated from a continuous, single piece, two (2) inch "extra strong" steel pipe conforming to the requirements of ASTM A53, Table X2. It must conform in detail with the mast arm shown on Drawing Number 661.

(b) 8-Foot Mast Arm. Each 8-foot mast arm must be fabricated from a continuous, single piece, two (2) inch "extra strong" steel pipe conforming to the requirements of ASTM A53, Table X2. It must conform in detail with the mast arm shown on Drawing Number 620.

(c) 12-Foot Mast Arm. Each 12-foot mast arm must be fabricated from two (2) continuous, single piece, two (2) inch "standard" steel pipes conforming to the requirements of ASTM A53, Table X2. It must conform in detail with the mast arm shown on Drawing Number 839.

(d) 15-Foot Mast Arm. Each 15-foot mast arm must be fabricated from two (2) continuous, single piece, two (2) inch "standard" steel pipes conforming to the requirements of ASTM A53, Table X2. It must conform in detail with the mast arm shown on Drawing Number 840.

(e) Mast Arm Attachment. The mast arm attachment to be welded to all mast arms will be a steel forging per ASTM A668, Class D, or cast steel conforming to the requirements for Grade 65-35 cast steel of ASTM A27, or can be fabricated from corrosion resistant steel plate such as "Cor-Ten" or approved equal. It must be so designed that it may be fitted over the mast arm supports on the pole and be held by the mast arm supports in proper position without other support. The attachment must conform to the details shown on Standard Drawing 724. Provision must be made for fastening the attachment to each mast arm support by two special screws and washers as noted in Section 6.

(f) Entryway for Wires. A drilled opening lined with a neoprene grommet

having inserted therein a neoprene plug must be provided on the underside of the upper member of all arms approximately three inches from the point of attachment. The clear opening must not be less than 5/8 inch in diameter. Its design must be submitted for approval by the Commissioner or his authorized representative.

(g) Mast Arm Members. All mast arm members must conform with the type of steel required for the arm specified. The members must be continuous lengths of pipe cut to the proper size to fabricate the mast arm lengths requested. No butt welded, swaged and welded or other pieced together configurations of pipe lengths will be accepted. The outer and inner surfaces of the pipes must be smooth and even without protrusions, nicks, holes or other imperfections.

PAINTING

4. (a) Oil and Grease Removal. All metal surfaces must be washed with an alkaline detergent to remove any oils or grease.

(b) Metal Cleaning. All exterior metal surfaces must be cleaned by blasting with a combination of shot and grit to remove all dirt, mill scale, rust, corrosion, oxides and foreign matter and provide a "near white" surface in accordance with SSPCS-SP10. Included in this process must be one to two inches of the interior section of the mast arm.

(c) Chemical Pretreatment. The cleaned metal surfaces must be treated with a hot, pressurized iron phosphate wash and must be dried by convection heat.

(d) Exterior Coat. A Thermosetting, polyester powder coat must be applied electrostatically to all cleaned and treated surfaces to a uniform eight (8) mil thickness in a one coat application. This powder coat must be cured in a convection oven at a minimum temperature of 400°F to form a high molecular weight fusion bonded finish.

(e) Alternate Methods. Alternate powder coat methods may be reviewed and tested on a case by case basis. However, no coating method will be accepted unless the Commissioner judges such alternate to be equal to the coating herein specified.

(f) Interior Coat. The interior metal surfaces must be powder coated with a thermoplastic hydrocarbon resin containing corrosion inhibitors. The resin must be formulated for application over untreated metal surfaces. The resin must be applied at a temperature of approximately 200°F to a minimum thickness of three (3) mils. The interior thermoplastic coat must overlap the interior, thermosetting base coat by approximately one (1) inch. Alternate interior coatings may be used subject to prior approval of the Commissioner.

(g) Durability. Both the exterior and interior coats must be capable of passing 1,000 hours of salt spray exposure as per ASTM B117 in a five percent (5%) NaC1 solution at 95°F and 95% relative humidity without blistering.

(h) Coating Measurement. Measurement of coating thickness must be done in accordance with SSPC-PA 2-73T, "Measurement of Dry Paint Thickness with Magnetic Gauges," except that the lowest "Single spot measurement" in an area of two square inches must be not less than 7.0 mils.

(i) Color. Color must be gloss black, unless otherwise specified in the order. A color chip sample must be submitted for approval prior to fabrication.

WELDING

5. (a) Standards. Every weld must be made in conformity with the proper interpretation of the standard welding symbols of the American Welding Society as indicated on the drawings; however, each bidder must submit with his proposal a drawing showing the sizes and types of welds, must state the type of electrode, and must describe the welding methods he proposes to employ in fabricating the mast arm.

(b) Testing. The welds must be inspected for penetration and soundness by the magnetic particle inspection method or by radiography. If the magnetic inspection process is used, the dry method with direct current must be employed.

SCREWS

6. Two (2) special 1/2" - 13 NC x 1-1/2" long stainless steel cap screws, and two (2) stainless steel flat washers, must be provided for each mast arm attachment.

MAST ARM TESTS

7. (a) General. Tests must be made upon three (3) of the first fifty (50) arms in any order. An additional one (1) arm must be tested for each additional fifty (50) arms in the order.

(b) 4-Foot Mast Arm. The 4-foot mast arm, when securely attached to a suitable and proper supporting structure, must withstand a side pull of not less than three hundred (300) pounds applied at a point three feet six inches (3'-6") from the connection to the supporting structure without failure of welds.

(c) 8-Foot Mast Arms. The 8-foot mast arm, when securely attached to a

suitable and proper supporting structure, must withstand a side pull of not less than three hundred (300) pounds applied at a point seven (7) feet from the connection to the supporting structure without failure of the welds.

(d) 12-Foot and 15-Foot Mast Arms. The 12-foot mast arm and the 15-foot mast arm, when securely attached to a suitable and proper supporting structure, must withstand a side pull of 300 pounds applied at a point seven (7) feet from the connection to the supporting structure without failure of the welds.

(e) Rejection. If any of the mast arms in any lot fail to meet the test, an additional three (3) arms in the same lot must be tested. If any of these mast arms fail to meet the test requirements the entire lot will be subject to rejection, except that the manufacturer may subject each mast arm in the lot to the test, and those which meet the requirements will be accepted.

(f) An Engineer from the Bureau of Electricity must be present to witness the testing procedures. If an engineer from the Bureau is unavailable, an independent consultant, approved by the Bureau, must witness and certify the tests. There will be no cost to the City for this. The contractor must include in his bid, the cost of travel, food and lodging for one (1) engineer. Travel for 150 miles or greater must utilize a major airline. Lodging accommodations must be equal to those provided at a Holiday Inn. The engineer must be given ten (10) working days notice of travel arrangements.

PACKAGING

8. (a) General. The arms must be shipped in bundles. Each arm must be individually wrapped so that the arm can be bundled for shipping and unbundled for delivery without damage to the arm or its finish. Materials such as lumber(2"x4" min.), non-marring banding, and other appropriate bundling materials must be used to make a rigid, long lasting, bundle capable of being handled , shipped and stored without shifting or breaking of the contents. Any bundles, in which either the mast arms or packaging is received broken, damaged or with contents shifted, will not be accepted and it will be the responsibility of the supplier to return the bundle at no cost to the City. Each bundle must be capable of being lifted by a fork lift truck or crane and the bundles must be shipped in a flat bed truck to facilitate unloading. Each arm wrapping must be clearly labeled indicating the arm size, i.e. 8' STEEL LUMINAIRE MAST ARM.

(b) The hardware must be shipped with each bundle. The package must be labeled and placed in a prominent position to facilitate accessibility, and must be attached to, or within, the bundle in such a manner as to assure safe delivery.

(c) All mast arms will be delivered to the Bureau of Electricity storage yard at

4101 South Cicero Avenue in Chicago, or to another location within the City as indicated on the order.

THIS SPECIFICATION MUST NOT BE ALTERED

SPECIFICATION 1457
BUREAU OF ELECTRICITY
DEPARTMENT OF STREETS
AND SANITATION
CITY OF CHICAGO
REVISED AUGUST 3, 2006

CABLE: SERVICE ENTRANCE, THREE INSULATED CONDUCTORS IN ONE OVERALL JACKET, 600 VOLT

SUBJECT

1. This specification states the requirements for a three conductor (two power conductors and one neutral conductor) Ethylene Propylene Rubber (EPR) insulated, chlorosulfonated polyethylene (CSPE) or polyvinyl chloride (PVC) jacketed cable for installation on Commonwealth Edison service poles for the purpose of providing secondary power feeds from Commonwealth Edison to a City disconnect mounted on the pole for street lighting or traffic signal circuits.

GENERAL

2. (a) Specifications. The cable must conform in detail to the requirements herein stated, and to the applicable portions of the specifications and methods of test of the following agencies:

(1) ICEA Specification S-95-658
(2) IEEE Standard 383
(3) ASTM Standard E-662-79
(4) ASTM Standard D-470-81
(5) U.L. 44
(6) U.L. 854

(b) Acceptance. Cable not conforming to this specification will not be accepted.

(c) Sample. A three (3) foot sample of the cable intended to be provided under this contract must be submitted to the Engineer of Electricity within fifteen (15) business days after receipt of such a request from the Chief Procurement Officer.

(d) Warranty. The manufacturer must warranty the cable to be first class material throughout. If the cable is installed within one year of the date of shipment, the manufacturer must replace any cable failing during normal and proper use within two years of installation. The cable length to be replaced

will be the entire unspliced length where the fault has been located. The Commissioner will be the sole judge in determining if a cable has failed and should be replaced. All replacements under this warranty must be made free of charge F.O.B. delivery point of the original contract

CABLE

3. (a) Construction. The cable must consist of three (3) conductors separately insulated and color coded. Suitable fillers must be used to produce essentially a round cross section in the completed cable. The insulated conductors must be cabled with a suitable left hand lay in conformance with the latest revision of ICEA S-95-658. A binder tape must be used over the cabled conductor assembly and a jacket applied overall.

(b) Sealing. The ends of each length of cable must be sealed against the entrance of moisture.

(c) Marking. The color of the neutral conductor must be white; that of the phase conductors must be black and red, respectively. The jacket must be black.

(d) Each conductor must consist of a round copper wire with a tight fitting, free stripping, concentric layer of Ethylene Propylene insulation. The cable must be rated for continuous duty at 90°C operating temperature, wet or dry, 130°C emergency overload temperature and 250°C short circuit temperature.

CONDUCTOR

4. (a) Material. The conductor must either be soft or annealed round copper wire, tin coated.

(b) Specifications. The conductor must meet the requirements of ASTM B3, and B8 for stranded Class B copper.

(c) Size. The conductor size must be as stated in the proposal or on the plans.

INSULATION

5. (a) Type. The insulation must be Ethylene Propylene compound meeting the physical and electrical requirements specified herein.

(b) Thickness. The insulation must be circular in cross-section, concentric to the conductor, and must have an average thickness not less than 30 mils (.030”) for #14 AWG, 55 mils (.055") for #4 AWG, 65 mils (.065”) for #2 AWG, 80 mils (.080") for #1/0 AWG, 80 mils (.080”) for #2/0 AWG ,and a spot thickness not less than ninety percent (90%) of the average thickness.

(c) Initial Physical Requirements:

(1) Tensile Strength, min., psi. 1200

(2) Elongation at Rupture, min. % 250

(d) Air Oven Exposure Test. After conditioning in an air oven at 121 ± 1°C for 168 hours using methods of test described in ASTM-D 573:

(1) Tensile strength, min% of unaged value 75

(2) Elongation, min % of unaged value at rupture 75

(e) Mechanical Water Absorption:

(1) Gravimetric Method: After 168 hours in water at 70 ± 1°C:

Water absorption, maximum
(Mg. per sq. in) 5.0

(f) Cold Bend Test Requirements. The completed cable must pass the "Cold-Bend, Long-Time Voltage Test on Short Specimens" of ASTM D-470 except that the test temperature must be minus (-) 25°C.

(g) Electrical Requirements.

(1) Voltage Test. The completed cable must meet an A.C. and D.C. voltage test in accordance with ASTM- D-470 and D-2655.

(2) Insulation Resistance. The completed cable must have an insulation resistance constant of not less than 20,000 when tested in accordance with methods shown in ASTM D-470.

JACKET

6. (a) Type. The jacket must be either a chlorosulfonated polyethylene (CSPE) or a polyvinylchloride (PVC) compound meeting the physical and electrical requirements specified herein. CSPE must meet the environmental requirements of CFR Title 40, Part 261 for leachable lead content.

(b) Thickness. The jacket must be circular in cross-section, concentric with the insulation, must have an average thickness not less than 45 mils (.045") for #14 AWG, 80 mils (.080") for #2 and #4 AWG, and not less than 95 mils (.095") for #1/0 and #2/0 AWG, and a spot thickness not less than ninety percent (90%) of the average thickness.

(c) Initial Physical Requirements:

(1) Tensile strength minimum PSI..... 1800
(2) Elongation at rupture, minimum percent 300

(d) Air Oven Exposure Test. After conditioning in an air oven at 121 ± 1°C for 168 hours:

(1) Tensile strength, minimum percent of unaged value 75
(2) Elongation at rupture, minimum percent of unaged value 60

(e) Mechanical Water Absorbtion. After 168 hours at 70 ± 1°C:

(1) Milligrams per square inch, maximum 20

TESTING

7. (a) General. Tests must be performed on insulation, jacket and completed cables in accordance with the applicable standards as listed in these specifications. Included in these tests will be a 70,000 BTU per hour flame test in accordance with IEEE 383. Where standards are at variance with each other or with other portions of this specification, the most stringent requirements, as determined by an engineer from the Bureau of Electricity, will apply. All tests must be conducted on cable produced for this order.

(b) Number of Tests. Insulation and jacket tests must be conducted on samples taken every 5,000 feet or fraction thereof of each conductor size. In no case must less than two (2) samples be taken. Approximately five percent (5%) of the cable must be tested. Where the cable fails to conform to any of the tests specified herein, samples must be taken from each reel and must successfully conform to all tests specified herein. Reels from which samples fail to conform, will be rejected.

(c) Witness Tests. If requested by the City, an engineer from the Bureau of Electricity must be present for testing. The contractor must include in his bid, the cost of travel, food and lodging for one (1) engineer. Travel for 150 miles or greater must utilize a major airline. Lodging accommodations must be equal to those provided at a Holiday Inn. The engineer must be given ten (10) working days notice of all travel arrangements.

(d) Test Reports. No cable may be shipped until certified copies of all factory tests have been reviewed and approved by the engineer.

PACKAGING

8. (a) Cable Marking. The cable must be identified by a permanently inscribed legend in white lettering as follows:

3/C - No. (conductor size)AWG-600V-90°C-EPR/CSPE or EPR/PVC-manufacturers name- month-year of manufacture

The legend must be repeated at approximately eighteen (18) inch intervals on the outside surface of the cable parallel to the longitudinal axis of the conductor.

(b) Reels. The completed cable must be delivered on sound substantial, non-returnable reels. Both ends of each length of cable must be properly sealed against the entrance of moisture and other foreign matter by the use of clamp-on cable caps. The ends must be securely fastened so as not to become loose in transit. Before shipment, all reels must be wrapped with cardboard or other approved wrapping.

(c) Footage. Each reel must contain 1,000 foot of cable for either #4 AWG or #2 AWG and 500 feet of cable for #1/0 AWG or #2/0 AWG. A tolerance limit of plus or minus ten percent (±10%) must be adhered to.

(d) Reel Marking. A metal tag must be securely attached to each reel indicating the reel number, contract number, date of shipment, gross and tare weights, description of the cable and the total footage. Directions for unrolling the cable must be placed on the reel with an approved permanent marking material such as oil-based paint or a securely attached metal tag.

TABLE 1 - THREE CONDUCTOR SERVICE ENTRANCE CABLE

Size (AWG)	Overall Diameter (mils)	No. Of Strands	Test Volts (KV)	Footage per Reel	Insulation (mils)	Jacket (mils)
4	950	7	4.5	1000	55	80
2	1100	7	4.5	1000	65	80
1/0	1400	19	5.5	500	80	95
2/0	1800	19	5.5	500	80	95

THIS SPECIFICATION MUST NOT BE ALTERED

SPECIFICATION 1458
BUREAU OF ELECTRICITY
DEPARTMENT OF STREETS
AND SANITATION CITY OF
CHICAGO
REVISED JULY 10, 2006

ELECTRICAL MANHOLE FRAMES AND COVERS 24 INCH AND 30 INCH DIAMETER

SCOPE

1. This specification describes the requirements for both 24 inch and 30 inch round frames and covers. These frames and covers will be used for electrical manholes and handholes and will provide access to the interior of the manholes and handholes. The 24 inch frames and covers will be used in parkway and sidewalk areas. The 30 inch frames and covers will be used in streets and in driveways and will provide sufficient strength to withstand normal traffic conditions.

GENERAL REQUIREMENTS

2. (a) Conformance. The manhole frames and covers must conform with every detail of the requirements herein stated and to the specifications and methods of test of the American Society for Testing and Materials cited by ASTM Designation Number in which the most recently published revision will govern.

(b) Acceptance. Frames and covers not conforming to this specification will not be accepted. The Commissioner of Streets and Sanitation will have the final say as to whether or not the frames and covers meet specifications.

(c) Drawings. The drawings mentioned herein are drawings of the Department of Streets and Sanitation, Bureau of Electricity, and must be interpreted as part of these specifications.

(d) Sample. Upon request, one complete manhole frame and cover of the manufacture intended to be furnished must be submitted within fifteen (15) business days after receipt of such a request from the Chief Procurement Officer. The samples must be delivered to the Bureau of Electricity, 4101 South Cicero Avenue, Chicago, Illinois.

(e) Warranty. The manufacturer must warrant that the frames and covers meet the specifications and warrant the frames and covers for a period of one (1) year from the date of delivery against defects which may occur during that period from normal and customary use. Any frame or cover which fails during this period must be replaced by the manufacturer at no cost to the City.

DESIGN

3. (a) The frames and covers must each conform in detail to the designs shown on Drawings 872, 874 and 10927.

(b) Each frame and cover must weigh approximately as shown on the drawings.

(c) Machining. The bearing surfaces of both the cover and the frame must be machine finished as indicated on the drawings.

(d) Workmanship. The frames and covers must be mutually interchangeable size for size, so that each lid will fit every frame neatly without jamming and with only such clearance as the drawings indicate. In addition, 24" & 30" covers must fit existing 24" & 30" frames, as shown on drawings 872, 874 and 10927. The castings must be neat, true to pattern and free from cracks and casting flaws. No welding of defective castings will be permitted nor must the castings be painted.

(e) Material. The frames and covers must be made of Class 30 Cast Iron described in the specifications for Gray Iron Castings of ASTM A48. No plugging of defective castings will be permitted.

TESTS

4. (a) Test bars of the metal used for the castings must be made and tested for tensile and transverse strength in accordance with ASTM A48. The metal must be tested at the works of the manufacturer. The manufacturer must furnish a certified copy of all test data sheets to the City prior to delivery of the castings. Frames and covers must each be considered a separate casting for determining the requirement of testing.

SPECIFICATION 1462
BUREAU OF ELECTRICITY
DEPARTMENT OF STREETS AND SANITATION CITY OF CHICAGO
REVISED AUGUST 3, 2006

RIGID STEEL CONDUIT (HOT DIPPED GALVANIZED)

SCOPE

1. This specification describes rigid steel conduit, zinc coated. This specification also describes rigid steel conduit that is both zinc and PVC coated. The conduit will be used underground or on structure as a raceway for electrical cables.

GENERAL REQUIREMENTS

2. (a) Rigid steel conduit must be zinc coated by the hot-dip process. Conduit must be furnished in 10 foot lengths, threaded on each end and with one coupling attached to one end and a protective cap at the other end.

(b) The conduit must be manufactured according to Underwriters Laboratories Standard U.L. - 6 and must meet ANSI Standard C 80.1 and the requirements of NEC Article 344. In addition, conduit must be recognized as an equipment grounding conductor as per NEC Article 250.118(2). There will be no exceptions to meeting these standards.

(c) Acceptance. Conduit not conforming to this specification will be rejected. The Commissioner will be the final judge in determining if the conduit meets the specification.

(d) Sample. If requested by the Chief Procurement Officer, a sample of conduit must be submitted to the Engineer of Electricity within fifteen (15) business days of receipt of such a request.

(e) Warranty. The manufacturer must warrant the construction and performance of the conduit to meet the requirements of this specification and must warrant all parts and components against defects due to design, workmanship, or material developing within a period of one (1) year after the conduit has been put in service.

STEEL

3. Conduit must be formed from steel suitable for use as an electrical raceway. It must be structurally sound so that it will hang straight and true when supported by hangers in accordance with Chicago electrical code requirements and must be capable of being field bent without deformation of the walls.

Conduit must have a circular cross section sufficiently accurate to permit the cutting of threads in accordance with Table 2 and must provide a uniform wall thickness throughout. All surfaces must be smooth and free of injurious defects. The dimensions and weights of rigid steel conduit must be in accordance with Table 1.

THREADING AND CHAMFERING

4. Each length of conduit, and each nipple, elbow and bend must be threaded on both ends, and each end must be chamfered to remove burrs and sharp edges.

The number of threads per inch, and the length of the threaded portion at each end of each length of conduit, nipple and elbow must be as indicated in Table 2. The perfect thread must be tapered for its entire length, and the taper must be 3/4 inch per foot.

ZINC COATING

5. After all cutting threading and chamfering all conduit surfaces must be thoroughly cleaned before application of zinc. The cleaning process must leave the interior and exterior surfaces of the conduit in such a condition that the zinc will be firmly adherent and smooth.

The conduit must be hot dipped galvanized both inside and out to provide approximately two (2) ounces of zinc per square foot. This is equivalent to 3.4 mils of zinc coating. An additional interior coating to aid in the installation of wires is required.

COUPLINGS

6. (a) The outside surface of couplings must be protected by means of a zinc coating. The zinc content of the coating on the outside surface must be equivalent to a minimum thickness of 3.4 mils.

(b) Couplings must be so made that all threads will be covered when the

coupling is pulled tight on standard conduit threads.

(c) Both ends of the coupling must be chamfered to prevent damage to the starting threads.

(d) The outside diameter, length and weight of coupling must be as indicated in Table 3.

(e) Couplings must be straight tapped, except that the 2 1/2 inch and larger sizes may be taper-tapped.

PVC COATED (WHEN SPECIFIED)

7. (a) Only hot dipped galvanized conduit, couplings, and fittings may be polyvinylchloride (PVC) coated.

(b) All conduit, couplings, and fittings must be cleaned before being coated.

(c) All conduit, couplings, and fittings must have a PVC coating applied to the exterior by dipping in liquid plastisol. The coating thickness must be a nominal 40 mils.

(d) All coated conduit, couplings, and fittings must conform to the requirements of NEMA Standard RN1- Section 3 , “External Coatings”. The latest revision will apply.

PACKING AND IDENTIFICATION

8. The pipe must be delivered in bundles. Each length of conduit must be marked with the manufacturer's name or trademark. Securely attached to each bundle at two (2) locations on the bundle must be a weather resistant tag containing the following information:

a. conduit size
b. footage of bundle
c. gross weight of bundle

Precaution will be taken by the contractor in handling during shipment or delivery of conduit, and any conduit found to be damaged will not be accepted.

TEST AND INSPECTION

9. Galvanized rigid conduit must be capable of being bent cold into a quarter of a circle around a mandrel, the radius of which is four times the nominal size of the conduit, without developing cracks at any portion and without opening

the weld.

The protective coatings used on the outside and inside surfaces of rigid steel conduit must be sufficiently elastic to prevent their cracking or flaking off when a finished sample of 2 inch conduit is tested within one year after the time of manufacture, by bending it into a half of a circle around a mandrel, the radius of which is 3 1/2 inches.

Tests on sizes other than 1/2 inch may be conducted within one year after the time of manufacture. If such tests are conducted, the conduit must be bent into a quarter of a circle around a mandrel, the radius of which is six times the nominal size of the conduit.

One of the following three test methods must be employed for measuring the thickness or extent of the external zinc coating on conduit:

(a) Magnetic test.
(b) Dropping test.
(c) Preece test (Material which will withstand four 1-minute immersions will be considered as meeting requirements as follows; the zinc content of the coating on the outside surface must be equivalent to a minimum thickness of 3.4 mils).

All tests and inspections must be made at the place of manufacture prior to shipment unless otherwise specified, and must be so conducted as not to interfere with normal manufacturing processes.

Each length of conduit must be examined visually both on the outside and inside to determine if the product is free from slivers, burrs, scale or other similar injurious defects (or a combination thereof), and if coverage of the coating is complete.

If any samples of rigid steel conduit tested as prescribed in this specification should fail, two additional samples must be tested, both of which must comply with the requirements of the specification.

All pipe which may develop any defect under tests, or which may before testing or on delivery be found defective, or not in accordance with these specifications, must be removed by the Contractor at his own expense; and such pipe so removed by the Contractor must be replaced by him within ten (10) days of such rejection with other pipe which will conform to these specifications.

TABLE 1

Design Dimension and Weights of Rigid Steel Conduit

Nominal or Trade Size Conduit	Inside Diameter	Outside Diameter	Wall Thickness	Length Without Coupling	Minimum Weight of Ten of Unit Length w/couplings
(Inches)	(Inches)	(Inches)	(Inches)	(Feet/Inches)	(Pounds)
1/2	0.622	0.840	0.109	9-11 1/4	79.00
3/4	0.824	1.050	0.113	9-11 1/4	105.0
1	1.049	1.315	0.133	9-11	153.0
1 1/4	1.380	1.660	0.140	9-11	201.0
1 1/2	1.610	1.900	0.145	9-11	249.0
2	2.067	2.375	0.154	9-11	334.0
2 1/2	2.469	2.875	0.203	9-10 1/2	527.0
3	3.068	3.500	0.216	9-10 1/2	690.0
3 1/2	3.548	4.000	0.226	9-10 1/4	831.0
4	4.026	4.500	0.237	9-10 1/4	982.0

NOTE: The applicable tolerances are:

Length: + 1/4 inch (without coupling)

Outside diameter: + 1/64 inch or -1/32 inch for the 1 1/2 inch and smaller sizes, ± 1 % for the 2 inch and larger sizes.

Wall thickness: - 12 1/2 %

TABLE 2

Dimensions of Threads

Nominal or Trade Size of Conduit (Inches)	Threads per Inch	Pitch Diameter at end of Thread (Inches)	Length of Thread (Inches)	
		Tapered 3/4 Inch per foot	Effective L2	Overall L4
1/2	14	0.7584	0.53	0.78
3/4	14	0.9677	0.55	0.79
1	11 1/2	1.2136	0.68	0.98
1 1/4	11 1/2	1.5571	0.71	1.01
1 1/2	11 1/2	1.7961	0.72	1.03
2	11 1/2	2.2690	0.76	1.06
2 1/2	8	2.7195	1.14	1.57
3	8	3.3406	1.20	1.63
3 1/2	8	3.8375	1.25	1.68
4	8	4.3344	1.30	1.73

NOTE: The applicable tolerances are:

Threaded Length (L4 Col 5): Plus or minus one thread

Pitch Diameter (Col 3): Plus or minus one turn is the maximum variation permitted from the gaging face of the working thread gages. This is equivalent to plus or minus one and one half turns from basic dimensions, since a variation of plus or minus one half turn from basic dimensions is permitted in working gages.

Designed Dimensions and Weights of Couplings **TABLE 3**

Nominal or Trade Size of Conduit (INCHES)	Outside Diameter (INCHES)	Minimum Length (INCHES)	Minimum Weight (POUNDS)
1/2	1.010	1-9/16	0.115
3/4	1.250	1-5/8	0.170
1	1.525	2	0.300
1 1/4	1.869	2-1/16	0.370
1 1/2	2.155	2-1/16	0.515
2	2.650	2 1/8	0.671
2 1/2	3.250	3-1/8	1.675
3	3.870	3-1/4	2.085
3 1/2	4.500	3-3/8	2.400
4	4.875	3-1/2	2.839

THIS SPECIFICATION MUST NOT BE ALTERED

ELECTRICAL SPECIFICATION 1464
DIVISION OF ELECTRICAL OPERATIONS
DEPARTMENT OF TRANSPORTATION
CITY OF CHICAGO
NOVEMBER 24, 1992

FUSES FOR STREET LIGHTING

SUBJECT

1. This specification covers the requirements for fuses to be used to protect street lighting circuits and luminaires. The fuses will installed in the fixture on fuse blocks, or in-line in in-line fuse holders.

DESIGN

2. (a) Fuses shall be rated for H.I.D. ballast and street lighting protection.

(b) Fuses shall be fast acting, high interrupting capacity and current limiting.

(c) Fuses must be rated for 10A, 600 VAC and 100,000 AMPS symmetrical interrupting.

(d) Fuse dimensions must be 13/32" x 1-1/2".

(e) Fuses must be U.L. listed.

(f) Fuses shall be Buss fuse type KTK; Littlefuse type KLK; Gould (Chase-Shawmut) type CTK; or approved equal.

**SPECIFICATION 1465
BUREAU OF ELECTRICITY
DEPARTMENT OF STREETS
AND SANITATION CITY OF
CHICAGO
REVISED JULY 12, 2006**

GROUND RODS

SUBJECT

1. This specification states requirements for ground rods and clamps to be used for ground electrodes in street lighting, traffic signal, and miscellaneous electrical circuits.

GENERAL

2. (a) Ground rods must be copper clad, steel rods suitable for driving into the ground without deformation of the rod or scoring, separation or other deterioration of the copper cladding.

(b) Sample. If requested by the Chief Procurement Officer, the contractor must furnish one sample of the ground rod proposed to be furnished within fifteen (15) business days from receipt of such request. The sample ground rod must be delivered to the Engineer of Electricity, 2451 S. Ashland Avenue, Chicago, Illinois 60608.

(c) Warranty. The manufacturer must warrant every ground rod against defects due to design, workmanship, or material developing within a period of one (1) year after the ground rod has been accepted. Any ground rod which fails during this period must be replaced by the contractor without expense to the City. The Commissioner of Streets and Sanitation will be the sole judge in determining which replacements are to be made.

(d) The Commissioner of Streets and Sanitation will be the sole judge in determining whether the submitted ground rods meet the requirements of this specification. Ground rods not accepted must be removed at the sole expense of the contractor.

DESIGN

3. (a) The ground rods and couplings must meet the latest requirements of (National Electrical Manufacturer's Association) NEMA Standard GR-1, for copper bonded ground rod electrodes and couplings. The ground rods must also meet the requirements of (Underwriter's Laboratories) UL 467.

(b) Ground rods must be made of steel core suitable for driving into the earth without deformation.

(c) A uniform covering of electrolytic copper, 10 mils in thickness, must be metallically bonded to the steel core to provide a corrosion resistant, inseparable bond between the steel core and the copper overlay.

(d) The finished rod must be of uniform cross-section; straight, and free of nicks, cuts or protuberances.

(e) The rod must be pointed at one end and chamfered at the other.

(f) All ground rods must be three-quarter inches (3/4") in diameter. The length must be as specified in the order or in the plans. The length and diameter of the rod and the manufacturer must be clearly and permanently marked near the top of the rod (chamfered end).

(g) All ground rods must have a ground clamp capable of accommodating a No. 6 AWG Copper Wire.

PACKING

4. (a) Ground rods must be packed in bundles with reinforced tape or plastic banding that will not damage the rods. Small bundles may then be bound in larger bundles held together with steel banding.

(b) Ground clamps must be packed in a suitable carton. The carton must be labeled to indicate the contents.

THIS SPECIFICATION MUST NOT BE ALTERED

SPECIFICATION 1467
BUREAU OF ELECTRICITY
DEPARTMENT OF STREETS
AND SANITATION
CITY OF CHICAGO
MAY 12, 1993

ROD: ANCHOR, STEEL, WITH HARDWARE

SUBJECT

1. This Specification states the requirements for steel anchor rods with hardware for the street light pole foundations.

GENERAL

2. (a) Specifications. The anchor rods must conform in detail to the requirements herein stated, and to the specifications of the American Society for Testing and Materials cited by ASTM Designation Number, of which the most recently published revision will govern.

(b) Drawing. The drawings mentioned herein are issued by the Department of Streets and Sanitation, and are an integral part of this specification.

ANCHOR ROD

3. (a) Fabrication. Each anchor rod must be fabricated in conformity with City of Chicago drawings numbered 806, 811, 830 and 844.

(b) Material. The rods must be fabricated from cold rolled carbon steel bar meeting the requirements of ASTM Specification A-36, except that the Specification must be modified to provide a minimum yield point of 55,000 psi (379 MPa).

(c) Thread. The straight end of each rod must be threaded as shown on City of Chicago drawing for that size rod, and must be American Standard, National Coarse.

HARDWARE

4. Hardware furnished with the anchor rod must be as shown on the applicable drawing. It must include two (2) hexagonal nuts, American Standard Regular, two (2) flat washers, type B, series W, and one (1) lock washer, steel, helical spring. The nuts must have a Class 2 or 3 fit.

FINISH

5. (a) Galvanizing. The threaded end of each rod must be hot dipped galvanized for the distance shown on the applicable drawing. The thickness of the galvanized coating must not be less than 0.0021 inches. Each hexagonal nut and washer must be galvanized to the minimum thickness required by ASTM A-153, Class C, or ASTM B-454, Class 50. After galvanization, each anchor rod and nut must have a mating fit equivalent to the American Standard Class 2 or 3 fit for nuts and bolts.

(b) Rust Inhibitor. With the hardware in place on the end of the bolt, the galvanized portion of the bolt must be coated with heavy No-Ox-Id or equal rust inhibiting greasy compound.

TESTS

6. At the discretion of the Commissioner, anchor rods and hardware furnished under this specification will be subject to testing to determine compliance with the materials physical requirements.

INSPECTION

7. Final inspection must be made at point of delivery. Any anchor rods and hardware rejected must be removed by the Contractor at his sole expense.

THIS SPECIFICATION MUST NOT BE ALTERED

SPECIFICATION 1474
BUREAU OF ELECTRICITY
DEPARTMENT OF STREETS
AND SANITATION CITY OF
CHICAGO
REVISED MAY 26, 2005

CABLE: TRAFFIC SIGNAL CABLE MULTIPLE CONDUCTOR, COPPER WIRE, 600 VOLT CROSS-LINKED POLYETHYLENE INSULATION LOW SMOKE ZERO HALOGEN JACKET

1. SUBJECT

This specification states the requirements for a multiple cable to be installed in underground conduits and uses to distribute electrical energy to operate automatic traffic control equipment at street intersections within the City of Chicago.

2. INDUSTRY STANDARDS

Cable manufactured per this specification must meet and/or exceed all requirements of the latest editions of the standards listed below. Where this specification differs from the requirements of the below standards, this specification must take precedence. The cable must further meet and/or exceed those applicable standards not stated herein but referenced by the below standards.

UL 44	Thermostat Insulated Wires and Cables
UL 1581	Reference Standard for Electrical Wires, Cables, and Flexible Cords
UL 1685	Vertical-Tray Fire Propagation & Smoke Release Test
IEEE 1202	Standard for Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies
IEEE 383	Flame Test Only / 210,000 BTU
ICEA T-29-520	Guide for Conducting Vertical Cable Tray Flame Tests With Theoretical Heat Input

	Rate of 210,000 B.T.U./Hour
ASTM B-8	Specification for Concentric-Lay-Solid Copper Conductor, Hard, Medium-hard, or Soft
ASTM B-33	Specification for Tinned Soft of Annealed Copper Wire for Electrical Purposes
ASTM D1894 *	Test method for Static and Kinetic Coefficients of Friction of Plastic Film and Sheeting
ASTM D2863	Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)

3. CABLES

(a) Construction. The cable must consist of coated conductors each concentri- cally encased with a XLPE Cross Linked Polyethelene insulation. In two-conductor cables, the insulated and covered conductors must be parallel and not twisted with suitable filler, as necessary, to produce a flat core minimum practicable dimensions. In the larger court cables suitable fillers must be used to produce an essentially round cross-section. A Mylar tape must b e wrapped over the conductor assembly, and low smoke zero halogen, jacket applied overall.

(b) Outer Diameter. The maximum allowable outer diameter for round cables must be as follows:

No. of Conductors	Outer Diameter (Inches)
Seven	0.49
Ten	**0.69**
Nineteen	**0.90**

(c) Sealing. Both ends of each length of cable must be thoroughly sealed to prevent the entrance of moisture and other foreign matter.

4. COLOR CODE

Conductor identification must be provided by color synthetic-resin coverings, or an approved equal.

(a) The conductor must be Class B solid, compressed uncoated copper in accordance with the applicable standards listed in section 2.

5. INSULATION

The insulation system must be a cross-linked polyethylene meeting and/or exceeding the appropriate standards listed in Section 2 and the values stated in the following table. The insulation system must be a Single Cross Linked Polyethyene thermosetting, polyolefin material, consisting of an XLPE, optimized for superior electrical properties and optimized for premium mechanical protection. The insulation must be compatible with the conductor and a mylar separator tape must be applied between the conductor and the insulation. The insulation thickness must be per ICEA S-95-658, Table 3, 1A Column A: and the outer layer must be filly colorable.

Conductor	**Stranding**	**No. of**	**Insulation**
Size AWG	**(No. Of Wires)**	**Conductors**	**(Thickness (mils)**
#14	**1**	**7**	**30**
#14	**1**	**10**	**30**
#14	**1**	**19**	**30**

6. CABLE TAPE

The assembled and cabled conductor core must be wrapped with a one mil (0.001 inch) thick Mylar tape allowing a minimum of ten percent (10%) overlap.

7. JACKET

(a) The jacket must be heavy low smoke zero halogen meeting the Physical and electrical requirements specified herein.

9. IDENTIFICATION

The insulation must be marked by means of surface or indent print with the following information; unmarked surfaces must not exceed 6 inches.

1. Manufacturer & plant of manufacture
2. Type and Size of Cable
3. Type of insulation, thickness and insulation level
4. Voltage Rating
5. Year of Manufacture
6. Sequential footage markings (at 2-foot minimum intervals)
7. US Cable Ratings:
   LS
   SUN RES
   CT USE (where applicable)
   UL 1685

10. PRODUCTION TESTS

Cable must be subjected to and pass all production tests as required by the appropriate standards listed in Section 2.

11. PACKAGING

(a) Reels. The completed cable must be delivered on sound substantial nonreturnable reels. Both ends of each length of cable must be properly sealed against the entrance of moisture and other foreign matter by the use of clamp-on cable caps, such as Reliable Electric Company neoprene cable cap No. 1405, or equal. The ends must be securely fastened so as not to become loose in transit.

(b) Footage. Each reel must contain the length of cable as set forth below. A tolerance limit of plus or minus five percent must be adhered to.

(1) Two-Conductor	2000 feet
(2) Seven-Conductor	2000 feet
(3) Ten-Conductor	2000 feet
(4) Nineteen Conductor	1000 feet

c ( ) Marking. A metal tag must be securely attached to each reel indicating the reel number, contract number, date of shipment, gross and tare weights, the appropriate City Commodity Code Number as set below, and a description of the cable. Also, each reel must have permanent marking on it indicating directions for unrolling the cable and the footage of cable contained in the reel. Indelible ink or other such material susceptible to washing off or fading will not be permitted; and approved permanent marking material such as paint or a securely attached metal tag is required.

(d) Commodity Code Number

(a)	Seven-Conductor	31-4686-5620
(b)	Ten-Conductor	**31-4686-5630**
(c)	Nineteen-Conductor	31-4682-5645

TABLE A COLOR CODE CONDUCTOR IDENTIFICATION

Base Color	First Tracer	Second Tracer	2 (# 6)	2 (# 4)	7	10	19
White	Black	Red	–	--	--	--	14
White	Red	Green	–	--	--	--	14
Black	--	--	6	4	14	14	14
White	--	--	6	4	14	14	14
Red	--	--	–	--	14	14	14
Green	--	--	–	--	14	14	14
Orange	--	--	–	--	14	14	14
Blue	--	--	–	--	14	--	14
White	Black	--	–	--	14	--	--
Red	Black	--	--	--	--	14	14
Green	Black	--	–	--	14	14	14
Orange	Black	--	--	--	--	14	14
Blue	Black	--	--	--	--	14	--
Black	White	--	--	--	--	--	--
Red	White	--	--	--	--	--	14
Green	White	--	--	--	--	--	14

THIS SPECIFICATION MUST NOT BE ALTERED

SPECIFICATION 1475
BUREAU OF ELECTRICITY
DEPARTMENT OF STREETS
AND SANITATION
CITY OF CHICAGO
REVISED SEPTEMBER 26, 2006

CORD: TRAFFIC SIGNAL, EIGHT CONDUCTOR NO. 16 AWG, 600 VOLT

SUBJECT

1. This specification states the requirements for an eight (8) conductor number 16 AWG, electrical cable, to be installed in poles and conduit and used to electrically energize traffic signal faces at street intersections within the City of Chicago. The cable must be flame retardant, have low acid gas content, good resistance to oil, moisture and mechanical abuse, and exhibit excellent heat aging and electrical characteristics.

GENERAL

2. (a) Specifications. The cable must conform in detail to the requirements herein stated, and to the Specifications and Methods of Test of the American Society for Testing and Materials cited by ASTM Designation Number, the Underwriters Laboratories, Inc. Standard or Style number and any other recognized Standardization group's specifications referred to by the appropriate designation, of which the most recently published revision will govern.

(b) Acceptance. Cable not conforming to this specification will not be accepted.

(c) Warranty. The manufacturer must warrant the cable to be first class material throughout. In addition to any other claims against them, if the cable is installed within six months of date of shipment, the manufacturer must replace any cable failing during normal and proper use within two years of date of installation. All replacements under this warranty must be made free of charge F.O.B. delivery point of the original contract.

(d) Sample. If requested by the Chief Procurement Officer, a three (3) foot sample of the cable intended to be provided under this specification must be submitted to the attention of the Engineer of Electricity within fifteen (15) business days after receipt of such request.

CABLE

3. (a) Construction. This cable must consist of stranded, coated, conductors each concentrically encased with a "free stripping," ethylene propylene rubber insulation. Suitable fillers must be used to produce an essentially round cross-section. The insulated conductors and the fillers must be cabled with a suitable left-hand lay as close together as is consistent with forming a core of minimum diameter. A Mylar tape must be wrapped over the conductor assembly, and a jacket applied overall.

(b) Outer Diameter. The maximum allowable outer diameter must be one-half (0.50) inch.

(c) Sealing. Both ends of each length of cable must be thoroughly sealed to prevent the entrance of moisture or other foreign matter.

MARKING

4. (a) Conductors. Identification must be provided by colors in accordance with I.M.S.A. Standards.

(b) Jacket. The outer jacket must be marked as follows: "8/C 16 AWG 600V 90ºC LSZH, name of manufacturer and date of manufacture. The height of letters must not be less than 1/8 inch in height and the message must repeat at approximately two (2) foot intervals. A sequential footage marking must be located on the opposite side of the jacket. All marking must be perfectly legible with permanent white ink.

CONDUCTOR

5. (a) Material. Round, Soft or annealed, stranded copper wire in accordance with ASTM B-3 and B-8, and coated in accordance with ASTM B33 (tin coated) , must be furnished.

(b) Size. The stranded conductor must consist of stranded wires twisted with an appropriate lay to form a No. 16 AWG conductor with an approximate diameter of 0.048 inches.

INSULATION

6. (a) Type. The insulation must be an easily strippable low smoke zero halogen (LSZH) thermosetting polyolefin compound or ethylene propylene rubber (EPR), or equal meeting or exceeding the requirements of ICEA S-95-658 and the additional requirements of this specification.

(b) Rating. The insulation must be rated for continuous duty at 90ºC in

accordance with U.L. AWM Style 3400.

(c) Thickness. The insulated conductor must be circular in cross-section, concentric to the conductor, with a nominal insulation thickness of 0.031 inches (2/64") and a minimum spot thickness of 90% of the nominal thickness.

(d) Initial Physical Requirements:

1. Tensile strength, min., PSI 1,600

2. Elongation at rupture, min. % 250

(e) Air Oven Exposure Test. After conditioning in an air oven at 158 ± 1ºC for 168 hours using methods of test described in ASTM-D 573:

Tensile strength, minimum percent of unaged value 85

Elongation at rupture, minimum percent of unaged value . . . .. .65

(f) Mechanicl Water Absorption:

1. Gravimetric Method. After 168 hours in water at 70± 1ºC:

Water absorption, maximum, milligrams per square inch . . .5.0

(g) Cold Bend Test Requirements. The completed cable must pass the "Cold-Bend," Long-Time Voltage Test on Short Specimens of ASTM D-470 except that the test temperature must be minus (-) 25ºC.

(h) Electrical Requirements:

1. Voltage Test. The completed cable must meet an A.C. and D.C. voltage test in accordance with ASTM D-470 and D-2655.

2. Insulation Resistance. The completed cable must have an insulation resistance constant of not less than 20,000 when tested in accordance with methods shown in ASTM D-470.

(i) Flexibility Tests. A sample length of insulated conductor must be formed in a loose coil, placed in a circulating air oven, and aged for 168 hours at 158º C ± 1ºC. The sample must then be allowed to cool to room temperature for one (1) hour and tightly wrapped around a 3X metal mandrel. The sample must show no cracks and must pass the same voltage test specified for the "Cold-Bend Test."

JACKET

7. (a) Type. The jacket must be a thermosetting low smoke zero halogen (LSZH) polyolefin compound or chlorinated polyethylene (CPE), or equal meeting the physical and electrical requirements specified herein.

(b) Rating. The jacket must be rated for continuous duty at 90º C.

(c) Thickness. The jacket must be circular in cross-section, concentric with the insulation, must have an average thickness not less than 45 mils and a spot thickness not less than ninety percent (90%) of the average thickness.

(d) Initial Physical Requirements:

1. Tensile strength minimum PSI	1800
2. Elongation at rupture, minimum percent	300

(e) Air Oven Exposure Test. After conditioning in an air oven at 121 ± 1ºC for 168 hours for LSZH or 136 ± 1ºC for CPE:

1. Tensile strength, minimum percent of unused value	75
2. Elongation at rupture, minimum percent of unaged valued	55

(f) Mechanical Water Absorption. After 168 hours at 70 ± 1º C:

1. Milligrams per square inch, maximum	20

TESTING

8. (a) General. Tests must be performed on insulation, jacket and completed cables in accordance with applicable standards as listed in this specification. Where standards are at variance with each other or with other portions of this specification, the most stringent requirements, as determined by an engineer from the Bureau of Electricity will apply.

All tests must be conducted on cable produced for this order. Where cable insulation and/or jacket thickness preclude obtaining samples of sufficient size for testing, special arrangements must be made with the engineer to obtain samples of unprocessed materials directly from the extrusion feed bins which will be separately processed and prepared for tests.

(b) Number of Tests. Insulation and jacket tests must be conducted on samples taken every 25,000 feet or fraction thereof of each conductor size. In no case must samples be taken closer than 15,000 feet apart.

(c) Witness Tests. Where the quantity of cable on a single purchase order is 100,000 feet or more, all insulation and jacket tests must be witnessed by an engineer from the Bureau of Electricity, if so requested by the City. Reels to be tested will be selected at random. The contractor must include in his bid, the cost of travel, food and lodging for one (1) engineer. Travel for 150 miles or greater must utilize a major airline. Lodging accommodations must be equal to those provided at a Holiday, Inn. The engineer must be given ten (10) working days notice of all travel arrangements.

(d) Test Reports. No cable must be shipped until certified copies of all factory tests, including witness tests where applicable, have been reviewed and approved by the engineer.

(e) Acceptance. Samples must be taken from each reel and must successfully conform to all tests specified herein. Reels from which samples fail to conform, will be rejected.

PACKAGING

9. (a) Reels. The completed cord must be delivered on sound, substantial reels. The ends of the cable must be securely fastened so that they will not become loose during shipment and handling.

(b) Footage. The number of feet per reel must be five hundred (500) feet plus or minus ten percent (±10%).

(c) Marking. A metal tag, or an approved indelible marking material such as alkyd enamel paint, must be used to mark the reel. The marking information must include, but not be limited to, the following: reel number, contract number, a description of the cord, and the footage of that particular reel.

ELECTRICAL SPECIFICATION 1487
DIVISION OF ELECTRICAL OPERATIONS
DEPARTMENT OF TRANSPORTATION
CITY OF CHICAGO
OCTOBER 31, 1997

POLE: ORNAMENTAL, LOOP STYLE, 10 FOOT 15" BOLT CIRCLE; STEEL, 7 GAUGE

SUBJECT

1. This specification states the requirements for an ornamental street light pole. These poles will support a twin mast arm bracket which will in turn, support two tenon mounted luminaires. A split pedestal base will be provided to cover the bottom 43.75" of the pole. This pole will be served by underground cables.

GENERAL

2. (a) Specifications. The poles shall conform in detail to the requirements herein, stated, and to the Specifications and Methods of Test of the American Society for Testing and Materials cited by ASTM Designation, of which the most recently published revisions will govern.

(b) Acceptance. Poles not conforming to this specification will not be accepted.

(c) Sample. One complete anchor-base pole of the manufacture intended to be furnished must be submitted within fifteen (15) business days upon request of the Chief Procurement Officer.

(d) Drawings. The drawings mentioned herein are drawings of the Department of Transportation, Division of Engineering, being an integral part of this specification cooperating to state the necessary requirements.

(e) Bidders Drawings. Bidders must submit with their bids scale drawings for the anchor base pole intended to be furnished. The drawings must show details of the pole design including the handhole, grounding and anchoring. Although the luminaire, the twin arm bracket and the split pedestal base are each covered by separate specifications, the drawing must include every dimension necessary to show how all parts and components will fit each other, be easily installed and maintained and be properly held in assembly.

(f) Interchangeableness. Each member including the handhole doors in the pole and the split pedestal base must be mutually interchangeable for assembly, so that no work will be required to make any member fit properly in the place of any other similar member of any other similar pole.

(g) Design. The pole must conform in design and dimensions to Drawing 911.

MASTS

3. (a) Mast Size. The mast size must be 10'-0"and must provide a 0.14" per foot taper. The mast diameter at a point 44" above the base must be 7.25". The mast must be rolled to provide a 16-flute pattern.

(b) Mast Design. The mast design must be as shown on Drawing 911.

(c) Material. The mast must be 7 gauge carbon steel in accordance with ASTM A595, Grade A and must provide a 0.14" per foot taper. The flutes must be neat, true to pattern and free from cracks and flaws. Each mast must be straight and centered on its longitudinal axis.

(d) Mast Base. The mast base must be a 1" thick steel plate of low alloy, high strength steel conforming to ASTM A 595, grade C, ASTM A 588 or ASTM A 606.

1. It must provide for mounting on a 15" bolt circle using 1" to 1 1/4" anchor bolts, nuts and washers provided by others. Any special hardware required must be provided by the Contractor.

2. It must provide sufficient internal clearance for two 3" conduit entries and a 3/4" ground rod.

3. The mast must be inserted into the base to a maximum depth which will still allow for an adequate weld to be made between the bottom of the mast and the plate. A circumferential weld must be made between the mast and the base at both the top and underside of the plate.

(e) Provision for Ground. A 1/2-13 square nut must be welded to the inside of the mast on the handhole entry frame for a ground connection.

(f) Entry. A vertical door frame carrying a removable door providing access to the interior of the mast must be welded into a close fitting opening centered approximately 15" above the bottom of the base. The door frame must be formed and welded of steel with cross section not less than 1-1/2" wide by

1/4" thick so as to adequately reinforce the opening of the mast. The internal horizontal clearance of the door frame must be 4"; its internal vertical height must be 8". Its upper and lower ends must be semi-circular meeting its straight sides tangentially. The frame must be drilled and tapped top and bottom to accept 1/4-20 hex head stainless steel machine screws.

(g) Door. The removable door must be formed of sheet steel approximately 1/8" thick. It must fit the door frame closely and be dished so that it will stay in proper position even if its locking screws must be slightly loosened. The door must be drilled top and bottom to accept the 1/4 -20 hex head stainless steel machine screws which will fasten the door to the door frame. Half sections of 3/8" x 1" tubing must be welded to the door concentric with the drilled holes to prevent removal of machine screws after installation. Alternate methods will be subject to approval by the Commissioner or his fully authorized representative.

(h) Tag. To each pole must be attached immediately above the handhole by mechanical means and not by adhesive, a stainless steel tag with a stamped or embossed legend which must include the pole outside diameter at the base, the overall length, and the gauge; i.e., 8.75" x 10'-7 gauge.

(i) With pole set in place and the door securely fastened, there must be no exposed wires, bolts or appurtenant hardware other than the door fasteners.

(j) Tenon. A tenon must be provided at the top of the pole for attachment of a twin mast arm bracket. The tenon diameter must be a minimum 5" I.P.S. pipe equivalent and must be sufficiently long to ensure positive, structurally sound mating between the mast and the attached device. The Tenon must be factory assembled to the mast. The finished mast must give the appearance of a single, homogeneous mast and the entire assembly must be structurally sound so that with the weight of a twin mast arm and two luminaires, the mast will not twist, rack, vibrate or otherwise deform when subjected to the severe vibrations of passing elevated trains or heavily loaded vehicles.

WELDING

4. (a) General. Where welds are required and approved, each welded joint must be made in conformity with the proper interpretation of the standard welding symbols of the American Welding Society. Each bidder must submit with his proposal a drawing showing the sizes and types of welds, must state the type of electrode and must describe the welding methods he proposes to use in fabricating the pole.

(b) Certifications. Welders must have proper certification for the welding operations required. Welding by non-certified personnel will not be allowed.

(c) Testing. All welds of 5% of the poles in every lot must be inspected for penetration and soundness of the welds by the magnetic particle inspection method or by radiography. Acceptance or rejection will be governed by the same conditions as in the testing section. If the magnetic inspection process is used, the dry method with direct current must be employed. All transverse welds must be magnetized by the "prod" (Circular Magnetization) method.

PAINTING

5. (a) Oil and Grease Removal. All metal surfaces must be washed with an alkaline detergent to remove oils and grease.

(b) Metal Cleaning. All exterior metal surfaces must be cleaned by blasting with a combination of shot and grit to remove all dirt, mill scale, rust, corrosion, oxides and foreign matter and provide a "near white" surface in accordance with SSPCS-SP10. Included in this process, the pretreatment process and the painting process must be the interior base section of the mast to a minimum height of 12".

(c) Chemical Pretreatment. The cleaned metal surfaces must then be treated with a hot, pressurized iron phosphate wash and must be dried by convection heat.

(d) Exterior Coat. A thermosetting, weathering, Polyester powder coat must be applied electrostatically to all cleaned and treated surfaces to a uniform 8-mil thickness in a one coat application. This powder coat must be cured in a convection oven at a minimum temperature of 400º Fahrenheit to form a high molecular weight fusion bonded finish.

(e) Alternate Methods. Alternate powder coat methods may be reviewed and tested on a case by case basis. However, no coating method will be accepted unless the Commissioner judges such alternate to be equal to the coating herein specified.

(f) Interior coat. The interior metal surfaces must be powder coated with a thermoplastic hydrocarbon resin . The resin must be applied at a temperature of approximately 200º Fahrenheit to a minimum thickness of 3 mils. The interior thermoplastic coat must overlap the interior, thermosetting base coat by approximately 6". Alternate interior coatings may be used subject to prior approval of the Commissioner.

(g) Durability. Both the exterior and interior coats must be capable of passing 1,000 hours of salt spray exposure per ASTM B117 in a 5% Na Cl (by weight) solution at 95º Fahrenheit and 95% relative humidity without

blistering. Before test, the panel must be scribed with an "X" down to bare metal.

(h) Coating Measurement. Measurement of coating thickness must be done in accordance with SSPC-Pa 2-73T, "Measurement of Dry Paint Thickness with Magnetic Gauges," except that the lowest "single spot measurement" in an area of two square inches must not be less than 7.0 mils.

(i) Color. Color must be gloss black. A color sample must be submitted for approval prior to fabrication. This color sample must include the manufacturer's name and the manufacturer's color name as well as any other information required to purchase the same color for the mast arms, luminaire and the split pedestal base.

(j) Field Touch-up. The Contractor must supply a field touch-up kit for every 20 poles or fraction thereof. The kit must consist of a highly legible instruction sheet, one gallon of the recommended touch-up paint and all other materials required to touch-up 20 light poles.

TESTING

6. (a) General. All completed masts shall be available for testing. Unless specifically authorized in writing, all tests must be performed at the manufacturer's plant. A record of every test must be made and a certified copy must be submitted to the Commissioner before the poles are shipped.

(b) Requirements. The following tests must be included in the testing procedure:

1. Coupon tests as outlined in ASTM A53 and A595, A588 or A606.

2. With the mast base rigidly secured using the normal mast mountings, a 1000 pound force must be incrementally applied, perpendicular to the mast at the tenon. This force must then be applied a second time at approximately the same location. The mast must then be checked to insure that the mast is still securely fastened; that it is plumb; and that no cracks have developed in either the mast, tenon or base.

3. Perform Weld tests as described in "welding" section.

(c) Acceptance. Tests must be made on 5% of all masts. If any of the masts fail to meet these tests, an additional three masts must be tested for each failed

mast. Should any of these additional masts fail to meet these test requirements, the entire lot will be subject to rejection. The Commissioner will then decide, based on the nature of the failure, whether the entire lot will be rejected outright or whether the manufacturer may subject each mast to testing, and those masts which fulfill the requirements will be accepted.

PACKAGING

7. (a) General. The poles shall be shipped in bundles weighing a maximum of 5,000 pounds. Each pole must be individually protected so that it can be bundled and unbundled, without damage to the pole or its finish. Where poles are delivered wrapped, specific instructions must be securely attached to each bundle indicating the proper methods of storage. In addition, each bundle must contain specific instructions on unbundling and erection of poles. Instructions must be printed on a fibre based paper with a permanent ink so that instructions will be completely legible after weathering outdoors for a minimum of 5 years.

(b) Bundles. The bundles shall consist of poles laid base to top to form an approximately rectangular cylinder. Materials such as lumber (2" x 4" min.), non-marring banding, and other appropriate bundling materials must be used to make a rigid, long lasting bundle capable of being handled, shipped and stored without shifting of contents or breaking. Bundling procedure will be subject to approval. Any bundles, in which either poles or packaging is received broken, damaged or with contents shifted, will not be accepted and it will be the responsibility of the supplier to return the bundle to its original destination at no cost to the City of Chicago. The bundles should be capable of being stacked two high without breaking, or shifting of the contents. Each bundle must be capable of being lifted by a fork lift truck or crane and the bundles must be shipped on a flat bed truck to facilitate unloading.

(c) Appurtenant Devices and Hardware. Any appurtenant devices and hardware not attached to the poles must be carefully wrapped and securely attached to each bundle. Payment will be withheld for any bundle delivered without the appurtenant devices and hardware. Cracked, broken, chipped or damaged parts will be considered as an incomplete delivery as regards payment.

(d) Touch-up Paint. Touch-up paint and appurtenant materials must be packaged in units sufficient for twenty (20) poles. These units will be securely attached to a sufficient number of bundles to fulfill the touch-up paint requirements stated herein.

ELECTRICAL SPECIFICATION 1488
DIVISION OF ELECTRICAL OPERATIONS
DEPARTMENT OF TRANSPORTATION
CITY OF CHICAGO
REVISED JULY 15, 2002

PEDESTAL BASE: ORNAMENTAL, FOR 10 FOOT LOOP STYLE POLE

SUBJECT

1. This specification states the requirements for an ornamental, pedestal base (Clamshell) for mounting on the ornamental 10 foot Loop Style light pole. This specification will address the requirements for a split aluminum base with aluminum doors, a fiberglass base without doors, and non-metallic doors only.

GENERAL

2. (a) Specifications. The pedestal bases and/or doors shall conform in detail to the requirements herein stated, and to the specifications and methods of test of the American Society for Testing and Materials cited by ASTM Designation Number, of which the most recently published revision will govern.

(b) Acceptance. Bases and/or doors not conforming to this specification will not be accepted. Whenever "approval" and "approved" are used in this specification they will mean approval by the Commissioner. The Commissioner's approval must be secured prior to proceeding with the manufacture of the bases and/or doors. The Commissioner will be the sole judge in determining if the submitted bases and/or doors are in compliance with the specification. The Commissioner's decision will be final.

(c) Drawings. The drawings mentioned herein are drawings of the Department of Transportation, Division of Engineering, being an integral part of this specification cooperating to state the necessary requirements.

(d) Bidders Drawings. Bidders must submit with their bids detailed scale drawings of the pedestal bases and/or doors, and any necessary attachments. The drawings must give every dimension necessary to show how the parts will fit each other and be properly held in assembly. Shop drawings must be original engineering drawings created by the manufacturer; photocopied or scanned copies of the Standard Drawings will not be accepted. If so requested by the City, these drawings will be submitted in electronic format,

preferably Microstation 95. Failure to provide drawings in this format will be cause for rejecting the submittal.

(e) Sample. One complete pedestal base and/or door of the manufacture intended to be furnished must be submitted within fifteen (15) business days upon request of the Chief Procurement Officer.

(f) Products. Bases and/or doors and component equipment must be products of established manufacturers, and must be suitable for the service required. Aluminum bases may be manufactured by Union Metal Corporation, Holophane Corporation, or an approved equal. Fiberglass bases or doors may be manufactured by Shakespeare Company, W.J. Whatley, Incorporated, or an approved equal.

(g) Warranty. The manufacturer shall warrant the performance and construction of the bases and/or doors to meet the requirements of this specification and shall warrant all parts and appurtenances against defects due to design, workmanship, or material developing within a period of three years after the bases and/or doors have been delivered. This will be interpreted particularly to mean structural or mechanical failure of any component, failure of any weld, or failure of any portion of the painting system. The warranty must be furnished in writing guaranteeing replacement, including cost of shipment, free of charge to the City. The Commissioner will be the sole judge in determining which replacements are to be made and the Commissioner's decision will be final.

(h) Design. The base and/or doors must conform to the design and dimensions of Standard Drawing 911.

OPTION 1. ALUMINUM BASE WITH DOORS

3. (a) Each split pedestal base must be cast aluminum conforming to ASTM B26, Grade A356. Each base must be certified as aluminum alloy A356.

(b) It must conform in detail with the split pedestal base shown on Drawing 911.

(c) Castings must have smooth external surfaces free from protuberances, dents, cracks or other imperfections marring their appearance. Welding or plugging of casting defects is prohibited. All castings and parts must be permanently labeled for easy identification.

(d) The two split base castings must be perfectly matched to each other and to the poles such that when they are attached to the mast, the base and mast assembly must appear as a one piece unit. No tolerance greater than 0.125" will be accepted.

(e) The split pedestal base attachment to the mast must provide the structural integrity to ensure the base will not vibrate, twist or bounce during the sidewalk movement experienced when an elevated train or heavily loaded vehicle passes. Where set screws are used to secure the base to the mast, a minimum of 3/16" thickness of metal must be provided where the set screws are inserted to minimize the possibility of stripping the threads when the set screws are tightened into place. The set screws must be 1/4" x 20 stainless steel Allen head screws. A minimum of four set screws must be provided. Set screws must be black.

(f) The split pedestal base must provide an entry door whose appearance and fit is in consonance with the mast and base design both aesthetically and structurally.

1. The door must be securely fastened in place with four 1/4"-20 hex head screws, which will thread into a rigid door frame. The door frame must be drilled and tapped. The door must be drilled only. The screws must be stainless steel.

2. All doors must be interchangeable with any other base. Bases whose doors are matched to a single base will be rejected.

3. The door must be positioned in the base such that the base can be attached to the mast with the base door, in perfect alignment with the mast door.

4. The door must provide ample room for a worker to reach into the base with hand tools, open the mast door, splice wires, change fuses and read the identification tag on the mast.

OPTION 2. FIBERGLASS BASE WITHOUT DOORS

4. (a) Each pedestal base must be formed of a fiberglass composite consisting of a polyester resin and containing a minimum of 65% fiberglass by weight. The resin must contain no clay fibers. The composite must be UV and weather resistant. Alternate materials may be considered. Each base half must be permanently marked on the inside identifying it as a base for the Loop Pole.

(b) The base must conform in detail and dimensions to Standard Drawing 911. With the exceptions that the material must meet the requirements of Section 6.a. and there will be no doors.

(c) The two halves of the clamshell must be identical to each other. They must be perfectly matched and when installed there must be no more than a 0.125 inch gap between the inside top of the assembled base and the outside surface

of the mast.

(d) Set screws must be used at the top of the base to attach the base to the mast, giving the base some rigidity and allowing the base to be positioned level. There must be four set screws (two in each half) evenly spaced at 90°. The set screws will be 1/4"-20 allen head steel screws. The set screws must be black.

(e) The color of the base must be gloss black and must match the color of existing and proposed Loop Poles. The resin must contain color pigment throughout. The pigment must be even throughout the base. A finish coat of urethane enamel must be applied to the surface of the base to a minimum dry thickness of 1.5 mils. The resin color must match the enamel color. A paint sample on fiberglass must be submitted for approval prior to production. The paint manufacturer's name and any information necessary to acquire the same color for the pole must be provided. The contractor must supply one quart of touch-up paint for every 50 bases ordered.

(f) The texture of the fiberglass base exterior must be equal to that of the aluminum cast base. Acceptance of the aesthetic appearance of the base will be by the Commissioner.

(g) The two halves of the clamshell must be affixed by means of screws. The screws must fit so that the halves of the base are drawn together as the screws are tightened. The halves should fit snug against each other. Threaded stainless steel inserts in the base must be used to affix the screws. The screws must be flush with the surface of the base and must not detract from the appearance of the base. Other methods of attachment may be considered. Any method of attachment must be approved by the Commissioner.

OPTION 3. NON-METALLIC DOORS

5. (a) Each base door must be formed of fiberglass (as described in Section 6.) or from another non-metallic material. The material must be UV and weather resistant. Any material other than fiberglass must be approved by the Commissioner. Each door must have a permanent marking on the back describing the part as a door for a Loop Pole.

(b) The door must conform to the detail and dimensions of Standard Drawing 911. All doors must be interchangeable.

(c) The color of the door must be gloss black and must match the color of the existing and proposed Loop Poles and bases. The non-metallic door must be pigmented throughout the material. The pigment must be even throughout the thickness of the door. A finish of urethane enamel must be applied to the door surface to a minimum dry thickness of 1.5 mils. A sample of the door

with paint must be submitted for approval prior to production.

(d) The door appearance must be of a texture and of a fit that it will appear to be a part of the original base. Acceptance of the aesthetic appearance and fit of the door will be by the Commissioner.

(e) The doors must be securely fastened in place with four 1/4"-20 hex head screws which will thread into the base frame. The door will be properly drilled to accept the screws. The door holes must not be tapped. The screws must be stainless steel. Screws must be supplied. Alternate methods of attachment will be considered.

WELDING FOR ALUMINUM BASES

6. (a) General. It is preferred that each half of the split pedestal base is cast as a single unit. Where the Contractor proposes to provide separate castings which are welded together, the Contractor must provide detailed drawings and a sample for the specific written approval of the Commissioner. Appearance will be a major factor in the approval process.

(b) Standards. Every weld must be made in conformity with the proper interpretation of the standard welding symbols of the American Welding Society as indicated on the drawings. Additionally, each bidder must submit with his proposal drawing the sizes and types of welds, must state the type of electrode, and must describe the welding methods he proposes to employ in fabricating the split base.

(c) Certification. All welds must be made by personnel who are certified for that type of welding. Welding by non-certified personnel will not be allowed.

(d) Testing. All welds of 5% of the bases in every lot must be inspected for penetration and soundness by means of radiography or by the magnetic particle inspection method. The proposed weld inspection method must be submitted with the proposal.

PAINTING OF ALUMINUM BASES

7. (a) Oil and Grease Removal. All metal surfaces must be washed with an alkaline detergent to remove oils and grease.

(b) Chemical Pretreatment. The cleaned metal surfaces must then be treated with a hot, pressurized phosphate wash and must be dried by convection heat.

(c) Exterior and Interior Coat. A thermosetting, weathering, Polyester powder coat must be applied electrostatically to all cleaned and treated surfaces to a

uniform eight-mil thickness in a one coat application. This powder coat must be cured in a convection oven at a minimum temperature of 400° Fahrenheit to form a high molecular weight fusion bonded finish.

(d) Alternate Methods. Alternate coating methods may be reviewed and tested on a case by case basis. However, no coating method will be accepted unless the Commissioner judges such alternate to be equal to the coating herein specified.

(e) Durability. Both the exterior and interior coats must be capable of passing 1,000 hours of salt spray exposure as per ASTM B117 in a 5% NaCl (by weight) solution at 95° Fahrenheit and 95% relative humidity without blistering. Before test, the panel must be scribed with an "X" down to bare metal.

(f) Coating Measurement. Measurement of coating thickness must be done in accordance with SSPC-Pa 2-73T, "Measurement of Dry Paint Thickness with Magnetic Gauges," except that the lowest "single spot measurement" in an area of two square inches must be not less than 7.0 mils.

(g) Color. Color must be gloss black. A color sample must be submitted for approval prior to fabrication. The color sample must include the manufacturer's name and the manufacturer's color name as well as any other information which will be required to purchase the same color for the mast, mast arm and luminaires.

(h) Field Touch-up. The Contractor must supply a field touch-up kit for every 20 bases or fraction thereof. The kit must consist of a highly legible instruction sheet, one gallon of the recommended touch-up paint and all other material required to touch-up 20 bases.

FABRICATION REQUIREMENTS FOR ALUMINUM BASES

8. (a) The manufacturer must demonstrate that the foundry proposed to fabricate the aluminum bases will meet or exceed the following requirements. The manufacturer must provide foundry qualifications using published capacity data. The manufacturer must identify the molding and core equipment proposed for use in fabricating the bases. The foundry must submit a written Quality Assurance Plan which includes testing.

TESTING

9. (a) General. All completed split pedestal bases and/or doors shall be available for testing. Unless specifically authorized in writing, all tests must be at the manufacturer's plant. A record of every test must be made and a certified

copy of the test record must be submitted to the Commissioner before the units are shipped.

(b) Requirements for aluminum bases. All aluminum bases shall be available for testing. The following tests must be included in the testing procedure:

1. Bar tests as outlined in ASTM B26.

2. Weld tests as described in Section 6.

(c) Requirements for fiberglass bases and non-metallic doors. All completed fiberglass bases and non-metallic doors shall be available for testing. The manufacturer must provide evidence that the bases and doors are structurally sound and are able to withstand the normal abuse of salt spray, freeze-thaw cycles, and exposure to moisture. The bases and doors must be impact resistant and must be resistant to UV damage.

(d) Acceptance Tests must be made on 5% of all the split pedestal bases and/or doors. If any of the units fail to meet these tests, an additional three units must be tested for each failed one. Should any of these additional units fail to meet these test requirements the entire lot will be subject to rejection. The Commissioner will then decide, based on the nature of the failure, whether the entire lot will be rejected outright or whether the manufacturer may subject each base and/or door to testing, and those units which fulfill the requirements will be accepted.

PACKAGING

10. (a) General. The split pedestal bases must be shipped on pallets with at least six units per pallet. Each base must be individually protected so that it can be bundled and unbundled without damage to the base or its finish. Where bases are delivered wrapped, specific instructions must be securely attached to each pallet indicating the proper methods of storage. In addition, each pallet must contain specific instructions on the installation of the split pedestal bases. Instructions must be printed on a fibre-based paper with a permanent ink so that instructions will be completely legible after weathering outdoors for a minimum of five years. Doors must be individually wrapped and packaged in cartons. The cartons must be labeled in 3/8 inch high lettering indicating the type of door (i.e. FIBERGLASS DOOR FOR LOOP LIGHT POLE BASE), the part number, the manufacturer, the date of manufacture, and the contract number.

(b) Appurtenant Devices and Hardware. Any appurtenant devices and hardware not attached to the bases must be carefully wrapped and securely attached to each pallet. Hardware for doors must be packaged in a clear bag with a label indicating the type of hardware, the quantity of hardware, and the associated

door type. Hardware for doors must be in the same carton as the doors. Payment will be withheld for any pallet or carton delivered without the appurtenant devices and hardware, or for any missing or improper packaging or labeling. Cracked, broken, chipped or damaged parts will be considered as an incomplete delivery as regards payment.

(c) Touch-up Paint. Touch-up paint and appurtenant materials must be packaged in units sufficient for the number of bases on each pallet. These units will be securely attached to each pallet.

ELECTRICAL SPECIFICATION 1489
DIVISION OF ELECTRICAL OPERATIONS
DEPARTMENT OF TRANSPORTATION
CITY OF CHICAGO
JUNE 9, 1997

MAST ARM: ORNAMENTAL, FOR LOOP STYLE POLE, FOR MOUNTING TWO ACORN LUMINAIRES, ALUMINUM

SUBJECT

1. This specification states the requirements for an ornamental aluminum twin mast arm for supporting two acorn luminaires on both the Loop pole and the Extended Loop pole.

GENERAL

2. (a) Specifications. The mast arms shall conform in detail to the requirements herein stated, and to the Specifications and Methods of Test of the American Society for Testing and Materials cited by ASTM Designation Number, of which the most recently published revision will govern.

(b) Acceptance. Mast Arms not conforming to this specification will not be accepted.

(c) Drawings. The drawings mentioned herein are drawings of the Department of Transportation, Division of Engineering, being an integral part of this specification cooperating to state the necessary requirements.

(d) Bidders Drawings. Bidders must submit with their bids detailed scale drawings of the mast arms and attachments proposed as the means for attaching these mast arms to poles. The drawings must give every dimension necessary to show how the parts will fit each other and be properly held in assembly.

(e) Sample. One complete mast arm of the manufacture intended to be furnished must be submitted within fifteen (15) business days upon request of the Chief Procurement Officer.

(f) Warranty. The manufacturer shall warrant that the mast arms meet the requirements of this specification and shall warrant the mast arms against any defects or failures that may occur within one (1) year of acceptance. Any

defective mast arm must be replaced by the manufacturer at no cost to the City.

DESIGN

3. (a) Each twin mast arm must be cast aluminum conforming to ASTM B26/B26M, Grade 319.

(b) It must conform in detail with the twin mast arm shown on Drawing 911.

(c) Castings must have smooth external surfaces free from protuberances, dents, cracks or other imperfections marring their appearance. Welding or plugging of casting defects is prohibited.

(d) Mast arms must be straight and true along both the longitudinal and vertical axis so that they will provide a perfect, parallel vertical mounting for the two luminaires.

(e) Mast arms must be structurally rigid so that when mounted on a mast, fitted with the capitals and luminaires shown on Drawing 911, and carrying two 4' x 14" banners with each top securely fastened to one side of the mast arm and each bottom securely fastened to the mast, neither an 80 m.p.h. AASHTO wind load, the vibration of a passing elevated train, nor the vibration of a heavily loaded vehicle will cause any twisting, racking or bouncing of the arm assembly in either the vertical or the horizontal plane.

(f) The mast arm attachment to the mast must provide the structural integrity to hold the mast arm firmly in place during the loading and vibration described above. Where set screws are used to secure the mast arm to the mast, a minimum of 3/16" thickness of metal must be provided where the set screws are inserted to minimize the possibility of stripping the threads when the set screws are tightened into place. The set screws must be 1/4" x 20 stainless steel Allen head screws and a minimum of three set screws must be provided.

(g) An access point near the top of the mast arm must be provided to facilitate wiring from the fixture to the mast handhole. The access point cover must be in architectural consonance with the mast arm and must be securely held in place with a minimum of two 1/4" x 20 stainless steel allen head set screws in a minimum of 3/16" thickness of metal. At this access point, a “J” hook must be provided to support the luminaire wiring so that rubbing on the interior raceway will be minimized.

(h) The interior of the mast arm must provide a smooth, burr-free raceway for the luminaire wiring.

(i) The mast arm must provide two 3"O.D. x 3" long tenons for attachment of

the luminaires.

WELDING

4. (a) General. It is preferred that the mast arm be cast as a single unit. Where the Contractor proposes to provide separate castings which are welded together, the Contractor must provide detailed drawings and a sample for the specific written approval of the Commissioner. Appearance will be a major factor in the approval process.

(b) Standards. Every weld must be made in conformity with the proper interpretation of the standard welding symbols of the American Welding Society as indicated on the drawings. Additionally, each bidder must submit with his proposal drawing the sizes and types of welds, must state the type of electrode, and must describe the welding methods he proposes to employ in fabricating the mast arm.

(c) Certification. All welds must be made by personnel who are certified for that type of welding. Welding by non-certified personnel will not be allowed.

(d) All welds must be inspected for penetration, soundness and appearance by means of radiography.

PAINTING

5. (a) Oil and Grease Removal. All metal surfaces must be washed with an alkaline detergent to remove oils and grease.

(b) Chemical Pretreatment. The cleaned metal surfaces must then be treated with a hot, pressurized phosphate wash and must be dried by convection heat.

(c) Exterior and Interior Coat. A thermosetting, weathering, Polyester powder coat must be applied electrostatically to all cleaned and treated surfaces to a uniform eight-mil thickness in a one coat application. This powder coat must be cured in a convection oven at a minimum temperature of 400 degrees Fahrenheit to form a high molecular weight fusion bonded finish.

(d) Alternate Methods. Alternate painting methods may be reviewed and tested on a case by case basis. However, no painting method will be accepted unless the Commissioner judges such alternate to be equal to the coating herein specified.

(e) Durability. Both the exterior and interior coats must be capable of passing 1,000 hours of salt spray exposure as per ASTM B117 in a 5% Na Cl (by weight) solution at 95° Fahrenheit and 95% relative humidity without blistering. Before test, the panel must be scribed with an "X" down to bare

metal.

(f) Coating Measurement. Measurement of coating thickness must be done in accordance with SSPC-Pa 2-73T, "Measurement of Dry Paint Thickness with Magnetic Gauges," except that the lowest "single spot measurement" in an area of two square inches must be not less than 7.0 mils.

(g) Color. Color must be gloss black. A color sample must be submitted for approval prior to fabrication. The color sample must include the manufacturer's name and the manufacturer's color name as well as any other information which will be required to purchase the same color for the mast, mast arm and luminaires.

(h) Field Touch-up. The Contractor must supply a field touch-up kit for every 20 bases or fraction thereof. The kit must consist of a highly legible instruction sheet, one gallon of the recommended touch-up paint and all other material required to touch-up 20 mast arms.

TESTING

6. (a) General. All completed mast arms shall be available for testing. Unless specifically authorized in writing, all tests must be at the manufacturer's plant. A record of every test must be made and a certified copy of the test record must be submitted to the Commissioner before the arms are shipped.

(b) Requirements. The following tests must be included in the testing procedure:

1. Bar tests as outlined in ASTM B26/B26M.

2. With the mast arm rigidly secured to a tenon equivalent to that of the pole and using the normal mast arm mounting provision, a 300-pound test load must be applied perpendicular to one end of the mast arm in the vertical plane for approximately 60 seconds. The test must then be repeated on the other end of the mast arm.

3. The 300-pound test load must then be applied to one end of the mast arm to create a twisting moment on the arm for approximately 60 seconds. The test must then be repeated on the other end of the mast arm.

4. The 300-pound test load must then be applied perpendicular to one end of the mast arm in the horizontal plane for approximately 60 seconds. The test must then be repeated on the other end of the mast arm.

5. The mast arm mounting must not be adjusted or retightened during

any of the above testing procedures.

6. During the tests, the mast arm must not rack, twist, bend or deform in any manner using measurement criteria and tolerances which will be mutually agreed upon by the Contractor and the Commissioner prior to testing. They must be based on normal testing procedures and the physical properties of the material.

7. At the completion of these tests, the mast arm must be in precisely the same position it was in at the start of testing and must not be structurally or visibly deformed in any matter whatsoever. Where welds are used in the manufacture of the arms, they must be subjected to testing by means of radiography to insure that they have not been compromised.

(c) Acceptance Tests must be made on 5% of all the mast arms. If any of the mast arms fail to meet these tests, an additional three mast arms must be tested for each failed mast arm. Should any of these additional mast arms fail to meet these test requirements the entire lot will be subject to rejection. The Commissioner will then decide, based on the nature of the failure, whether the entire lot will be rejected outright or whether the manufacturer may subject each mast arm to testing, and those mast arms which fulfill the requirements will be accepted.

PACKAGING

7. (a) General. The mast arms shall be shipped on pallets of 6 mast arms. Each base must be individually protected so that it can be bundled and unbundled without damage to the mast arm or its finish. Where mast arms are delivered wrapped, specific instructions must be securely attached to each pallet indicating the proper methods of storage. In addition, each pallet must contain specific instructions on the installation of the mast arms. Instructions must be printed on a fiber-based paper with a permanent ink so that instructions will be completely legible after weathering outdoors for a minimum of five years. Any pallets, in which either mast arms or packaging is received broken, damaged or with contents shifted, will not be accepted and it will be the responsibility of the supplier to return the pallet to its original destination at no cost to the City of Chicago.

(b) Appurtenant Devices and Hardware. Any appurtenant devices and hardware not attached to the mast arm must be carefully wrapped and securely attached to each pallet. Payment will be withheld for any pallet delivered without the appurtenant devices and hardware. Cracked, broken, chipped or damaged parts will be considered as an incomplete delivery as regards payment.

(d) Touch-up Paint. Touch-up paint and appurtenant materials must be packaged in units sufficient for the number for 20 mast arms. These units will be securely attached to each bundle.

**SPECIFICATION 1493
BUREAU OF ELECTRICITY
DEPARTMENT OF STREETS
AND SANITATION CITY OF
CHICAGO
MARCH 20, 2000**

TRAFFIC SIGNAL: VEHICULAR, TWELVE-INCH SINGLE FACE, SINGLE OR MULTIPLE-SECTION, POLYCARBONATE, LED OR INCANDESCENT

12. GENERAL REQUIREMENTS

1.1 This specification states the requirements for twelve-inch, single face, single and multiple-section, traffic signals with polycarbonate housings, using LED or incandescent light source, for use in the traffic control system of the City of Chicago. Units include red ball, yellow ball, green ball, red arrow, yellow arrow, and green arrow.

1.2 Sample and Certified Test Reports. One complete signal, fully assembled and wired, of the manufacture proposed to be furnished, must be submitted along with the required certified test reports, within fifteen (15) business days upon request of the Chief Procurement Officer. The sample must be delivered to the Engineer of Electricity, Bureau of Electricity, 2451 South Ashland Avenue, Chicago, Illinois 60608.

1.3 Standards. Equipment furnished under this specification must meet the appropriate requirements of the following standards, as required within the body of this specification:

American Association of State Highway and Transportation Officials (AASHTO)
American Society for Testing and Materials (ASTM)
Institute of Transportation Engineers (ITE)
National Electrical Manufacturers Association (NEMA)
Underwriters Laboratories (UL)

1.4 Approval. Approval will mean approval in writing by the Commissioner or his/her duly authorized representative.

1.5 Warranty. The manufacturer must warrant the signals to meet the requirements of this specification, and must warrant all equipment, components, parts and appurtenances against defective design, material and workmanship for a period of three (3) years from date of acceptance. In addition, LED optical units must carry a

seven (7) year warranty against failure or loss of color (chromaticity) and signal brightness (luminance) below minimum acceptable VTCSH standard levels from date of final acceptance for contract construction, or date of delivery on a specific order. In the event defects or failures occur in the LED units during the warranty period, the manufacturer must replace all defective units, at no expense to the City. This warranty must be evidenced by a letter or certificate of warranty submitted to the City at the time delivery is made. The LED warranty must cover all units delivered in an order or installed by contract, and must include unit serial numbers. The warranty must be signed and dated by an official of the manufacturer who is empowered by the manufacturer to enter into such a warranty.

2. MATERIALS AND EQUIPMENT REQUIREMENTS

2.1 The traffic signal heads must conform to ITE Standard "Vehicle Traffic Control Signal Heads" (VTCSH), in which the most recently published revision will govern.

2.2 Housing. The housing of each section must be one piece, ultraviolet stabilized polycarbonate resin of the specified color, injection molded complete with integral top, bottom, and sides, having a minimum thickness of 0.1 inch.

(a) The polycarbonate must meet or exceed the following tests:

TEST	REQUIRED	METHOD
Specific gravity	1.17 minimum	ASTM D 792
Vicat Softening temp	310-320º F	ASTM D 1525
Brittleness temp.	-200º F	ASTM D 746
Flammability	Self-extinguishing	ASTM D 635
Tensile strength, yield	8,500 PSI	ASTM D 638
Elongation at yield	5.5-8.5%	ASTM D 638
Shear strength, yield	5,500 PSI min.	ASTM D 732
Izod impact strength (notched, 1/8" thick)	12-16 ft-lbs/in.	ASTM D 256
Fatigue strength (at 2.5 mm cycles)	950 PSI min.	ASTM D 671

(b) Assembly. A traffic signal section must be comprised of, but not limited to, the housing, hinged door, visor, optical unit and all necessary gaskets and hardware. The multi-section, single face, traffic signal must be comprised of single face single sections assembled together, containing an internally mounted terminal block. Arrow indications must be shipped as single sections. The traffic signals must be designed and constructed to permit sections to be assembled together, one above the other, forming a weatherproof and dust-tight unit.

(c) Individual sections must be fastened together with a coupling washer assembly composed of two washers, three zinc plated bolts, nuts, and lock

washers which lock the individual sections together. As an alternative, individual sections may be fastened together with four cadmium plated bolts, lock washers, and nuts. The hole in the coupling washer assembly must accommodate three 3/4 inch cables.

(d) Height. The overall height of an assembled traffic signal must be fourteen (14) inches for a single-section signal, forty-two (42) inches for a three-section signal, and seventy (70) inches for a five-section, plus or minus one (1) inch.

(e) Mounting. The traffic signal must be designed for mounting with standard traffic signal brackets using 1-1/2 inch pipe size fittings.

(f) Positioning Device. The top and bottom opening of each housing must have integral serrated bosses that will provide positive positioning of the signal head in five degree increments. A total of 72 teeth must be provided in the serrated bosses to allow the signal face to be rotated 360 degrees about its axis. The teeth must be clean and well defined to provide positive positioning.

(g) Hinges. The signal housing must be sectional; one section for each optical unit. Each housing must have four integral hinge lugs, with stainless steel hinge pins (AISI 304 or equivalent), located on the left side for mounting the door. The hinge pins must be straight and not protrude past the outside of the housing lugs. The housing must have two integral latching bolt lugs on the right side each with a stainless steel hinge pin to which a latching bolt (AISI 304 or equivalent), washer, and wing nut will be attached. The wing nuts must be captive. Each housing must be equipped with holes to be used for mounting backplates.

(h) Door. The door must be a one piece ultraviolet stabilized polycarbonate resin of the specified color, injection molded complete with a minimum thickness of 0.1 inch. Two (2) hinge lugs on the left side and two (2) sets of latch screw jaws centered on the right side, as viewed from the front of the signal, must be integrally cast with the housing door. The door must be hinged to the housing with two (2) stainless steel hinge pins, drive fitted. Two (2) stainless steel latch screws and wing nut and washer assemblies on the latch side of the housing body must provide for opening and closing the door without the use of tools. The door must have eight (8) holes with threaded metal inserts for stainless steel machine screws to secure the visor(4 holes) and the lens(4 holes). The inside of the door must be grooved to accommodate a one piece, air-cored EPDM (ethylene propylene diene monomer) gasket to provide a weatherproof and dust proof seal when the door is closed. The inside of the door must have four equally spaced threaded metal inserts for the lens attachment. The outside of the door must have an integral rim completely encircling the lens opening to prevent leakage

between the door and the lens. The rim must have four equally spaced tabs around the circumference with threaded metal inserts for the visor.

(i) Visor Each traffic signal must have a visor for each signal indication (section). The visor must be the tunnel type, nine and one-quarter inches (9-1/4") long, fabricated of ultraviolet stabilized polycarbonate resin of the specified color, injection molded. The visor must fit tightly against the door and not permit any light leakage between the door and visor. All hardware necessary for, but not limited to, attachment of the visor must be of stainless steel. The visor must have four mounting lugs for attaching the visor to the door. Screws must go through the visor lugs into the metal inserts in the door to secure the visor.

2.3 The traffic signal heads must be provided with incandescent or LED optical units as specified in the line item or Contract Plans.

2.3.1 INCANDESCENT OPTICAL UNITS

(a) Incandescent Optical Unit. The incandescent optical unit consists of the lens, reflector and lamp holder. The optical unit and visor must be designed as a whole so as to eliminate the return of outside rays entering the unit from above the horizontal (known as sun phantom). The optical unit must be designed and assembled so that no light can escape from one indication to another.

(b) Lenses. The red, yellow and green polycarbonate lenses must be round with a nominal twelve (12) inch diameter and must conform to all requirements set forth under the heading "Traffic Signal Lenses" in the ITE standard. The red, green or yellow arrow lenses must be round with a nominal twelve (12) inch diameter and the outside surface must be covered, except for the arrow, with a dull or dark grey opaque material of a thickness sufficient to totally hide the light from a 2000-lumen lamp placed behind it operating at rated voltage. The opaque material must be hard and durable and must be bonded such that it will not peel or flake when subject to the heat of a signal lamp or when the lens is washed. The shape and size of the arrow must be of an approved design with a minimum stroke of fifteen-sixteenths (15/16) inch. The arrow must appear uniformly illuminated when viewed from angles usually encountered in service, whatever may be the angular position of the lens in the signal section. The lens must be enclosed by an air-cored EPDM (ethylene propylene diene monomer) gasket providing a weather proof and dust proof seal between the lens, door, and reflector assembly. The gasketed lens must be secured to the housing door by four (4) stainless steel screws (AISI 304 or equivalent) and clamps equally spaced around the lens opening. The door must have threaded metal inserts to receive the screws.

(c) Reflector. The reflector must be fabricated of high-purity, clad-type

aluminum sheet formed to a parabolic shape and cut to fit in a circular polycarbonate, hinged frame for rigid mounting within the housing. The circular rim of the reflector must be mounted in such a way as to seal the internal optical system by being compressed against the lens gasket when the signal door is closed. The reflecting surface must be an "ALZAK" class SI specular finish having a minimum reflectivity of eighty-two (82) percent and a protective oxide coating of 7.5 milligrams per square inch, minimum. The reflectivity must be determined with a Taylor-Baugartner Reflectometer, and the weight of the protective oxide coating by the method of test outlined in ASTM B 137. The reflecting surface must be tested for proper sealing by applying one (1) drop of a water solution (1 gram per 50 cc) of Anthraquinone Violet R at a room temperature. After five (5) minutes, the dye must be washed from the surface with running water. No stain must remain after the surface is lightly rubbed with a soft cloth wet with mild soap and water, and rinsed with water. The reflector must have an opening in the back to accommodate the lamp holder.

(d) Lamp Holder. The lamp holder must have a heat, moisture and weatherproof molded phenolic housing designed to accommodate a standard 133 watt, 3 inch light center length, incandescent lamp. The lamp holder must be so designed that it can be readily rotated and positively positioned to provide proper lamp filament orientation and focus. The inner brass shell, or ferrule, of the lamp holder must have a grip to prevent the lamp from working loose due to vibration. A gasket must be furnished at the junction of the lamp holder and the reflector.

2.3.2 LIGHT EMITTING DIODE (LED) OPTICAL UNITS

(a) Light emitting diode (LED) optical units must consist of an integral unit containing the following components: power leads, housing, integral lens, matrix of light emitting diodes (LEDs) emitting monochromatic light of desired signal color, and electronic and electrical components necessary to permit operation at nominal 120 volt, 60 hertz power.

(b) The LED unit must be of such dimensions as to permit mounting in any standard traffic signal housing, be interchangeable with incandescent optical units, and must include appropriate gasket for this purpose. Gasketing provided must provide a watertight seal meeting existing ITE standard for signal heads, and exclude the infiltration of moisture into either the signal housing or into the LED optical unit case.

(c) The LED unit must meet the applicable requirements of the ITE standards for Vehicle Traffic Control Signal Heads (VTCSH) Part 2: LED Vehicle Signal Modules, for color (chromaticity), signal brightness (luminance), and beam spread (luminance at various vertical and horizontal angles). Yellow LED

modules must meet the green module requirements for brightness.

(d) Minimum brightness of LED signal units must be in accordance with the luminous requirements in a standard testing procedure as defined by Section 4 of the VTCSH Part 2: LED Vehicle Signal Modules. During the required operating life of LED signal units, the luminance output of the units must not be less than 60 percent (.60) of the values specified in the standard.

(e) Unit lenses must be twelve inches in diameter and be constructed of ultraviolet (UV) stabilized, impact resistant polycarbonate, acrylic or other approved material. Lenses must be clear or tinted.

(f) Units must consist of LEDs uniformly distributed to present a homogeneous appearance on the face of the lens from a wide viewing angle.

(g) LEDs must be wired so that the loss of a single LED or a string of LEDs will not reduce the luminescence below the minimum requirement.

(h) For purposes of this specification, failure of a single unit is defined as an occurrence where the luminescence of the signal measured in candela in standard test procedures is less than the required initial luminance or luminance at time points and conditions specified; or where minimum required brightness is achieved, but two or more series strings of LEDs or in excess of twenty percent of 20% of LEDs are not operable.

(i) Unit power supply must be constant current regulated and filtered to provide instant on indications, and to prevent momentary signal outages or flicker. Units must be fully operable over a range of 90 volts to 130 volts at 60 hertz, plus or minus 3 hertz.

(j) Surge protection: Each unit must be provided with integral surge protection to withstand transient of 600 volt, 100 microsecond rise and 1 millisecond pulse width. The surge protector must provide full electrical and physical protection to all unit components.

(k) Maximum permissible power consumption at ambient conditions (nominal 120 volts, 60 hertz, 70 degrees F.) must be 30 watts at a minimum 90 percent power factor. Power consumed must not vary by more than ten (10) percent from nominal power consumption over voltage range of 105 volts to 125 volts, and over permissible environmental ranges.

(l) Units must be fully operable at temperature ranges of -40 degrees F. (-40 deg C) to +165 degrees F. (+74 deg C) at up to 100 percent relative humidity.

(m) Units must be clearly marked on the back surface of the unit in a permanent manner showing information required for warranty and long term performance. Information to be shown must include manufacturer name, date of manufacture, electric power requirements, signal model type including color and indication type, and signal serial number.

(n) The LED unit must be compatible with the traffic signal controller equipment currently in use by the City of Chicago, and meeting the City's latest specifications for traffic signal control equipment. In particular the LED unit must be compatible with the NEMA TS-1 and later traffic signal load switches and conflict monitors.

(o) Units must meet applicable sections of Title 47, SubPart B, Section 15 of the Federal Communications Commission (FCC) rules as applies to electronic noise limitation and electromagnetic interference.

(p) Total harmonic distortion (THD) induced into the voltage and current AC power line sine waves must not exceed 20 percent.

(q) LED optical units must meet the requirements of VTCSH Part 2: LED Vehicle Signal Modules Section 6.3.1 for signal burn-in.

2.4 Wiring. Each lamp holder must be furnished with two (2) leads color coded as follows:

White	Common
Red	Red Lens Section
Yellow	Yellow Lens Section
Green	Green Lens Section
Green with Black Tracer	Green Arrow Lens Section
Yellow with Black Tracer	Yellow Arrow Lens Section
Red with Black Trace	Red Arrow Lens Section

The lead must be type TEW No. 18 AWG stranded copper wire with 2/64 inch thick, 600 volt, 105 degree centigrade rated, thermo-plastic insulation meeting MIL-W-76A specifications. The lead must connect to the terminal strip without being spliced. The ends of the lamp leads must be stripped of one-half inch (2") of insulation and tinned.

2.5 Terminal Strip. A dual-point, barrier type terminal strip with a solid base and pressure plate type connectors (Marathon Special Products Corporation Catalog No. TB-305-SP, or equal) must be securely attached at both ends to the housing body inside the "Green" section of the signal head.

2.6 Cable. One, eleven foot (11') length of flexible electric cord, medium duty, type SO, No. 16 AWG stranded copper conductor, color coded, rubber insulated, neoprene jacketed, must be furnished with each signal head. The number of conductors must include neutral, ground, and one switch leg for each section. Both ends of each cable length must be carefully stripped of six inches (6") of jacket and one inch (1") of insulation, and each conductor properly tinned.

2.7 Gaskets. Wherever necessary to make a completely dustproof, moistureproof and weatherproof assembly of the housing and optical system, approved type gaskets of neoprene or silicone rubber must be provided.

3. TESTING AND DOCUMENTATION REQUIREMENTS

3.1 Documentation. The contractor must provide certified manufacturing and testing documentation to demonstrate that the traffic signals being supplied meet or exceed the specification requirements. The LED Optical Units must be tested by an independent and certified testing laboratory.

3.2 Inspection. The signals will be subject to inspection at the discretion of the Commissioner. Final inspection must be made at point of delivery. Any signal rejected must be removed and disposed of by the contractor at his sole cost.

4. PACKING

4.1 Packing. Each traffic signal assembly must be packed in a suitable carton so secured that the signal will not be damaged during shipment, handling or storage.

4.2 Marking. Each carton containing a traffic signal must be clearly marked on the outside in letters not less than three-eighths (3/8) inch tall with the legend: "TRAFFIC SIGNAL, TWELVE-INCH, POLYCARBONATE@ or ATRAFFIC SIGNAL, TWELVE INCH, POLYCARBONATE, LED OPTICS@and the number of Sections as required, the color and indication types, the name of the manufacturer, the date of manufacture, the pertinent Contract Number and the appropriate City Commodity Code Number.

SPECIFICATION 1495
BUREAU OF ELECTRICITY
DEPARTMENT OF STREETS
AND SANITATION CITY OF
CHICAGO
MARCH 20, 2000

TRAFFIC SIGNAL MOUNTING BRACKET POLYCARBONATE, SIDE OF POLE

SCOPE

1. This specification states the requirements for polycarbonate brackets designed for mounting 12 inch traffic and pedestrian signal heads from the side of poles.

GENERAL REQUIREMENTS

2. (a) Sample and Certified Test Reports. One complete signal bracket of the manufacture proposed to be furnished, must be submitted along with the required certified test reports, within fifteen (15) business days upon request of the Chief Procurement Officer. The sample must be delivered to the Engineer of Electricity, Bureau of Electricity, 2451 South Ashland Avenue, Chicago, Illinois 60608.

(b) Standards. Equipment furnished under this specification must meet the appropriate requirements of the following standards, as required within the body of this specification:

American Association of State Highway and Transportation Officials (AASHTO)
American Society for Testing and Materials (ASTM)
Institute of Transportation Engineers (ITE)
National Electrical Manufacturers Association (NEMA)

(c) Approval. Approval will mean approval in writing by the Commissioner or his/her duly authorized representative.

(d) Warranty. The manufacturer must warrant the signal bracket to meet the requirements of this specification, and must warrant all equipment, components, parts and appurtenances against defective design, material and workmanship for a period of three (3) years from date of acceptance. In the event defects and failures become apparent during this period, the

manufacturer must repair or replace such defects and failures at no expense to the City. This warranty must be evidenced by a letter or certificate of warranty submitted to the City at the time final delivery is made.

MATERIAL

3. (a) The bracket must be one piece, ultra violet stabilized polycarbonate resin of the specified color, injection molded complete with integral top, bottom, and sides.

(b) The polycarbonate formulation used must provide these physical properties in the bracket (Tests may be performed on separately molded specimens).

TEST	REQUIRED	METHOD
Specific gravity	1.17 minimum	ASTM D 792
Vicat Softening temp	310-320° F	ASTM D 1525
Brittleness temp.	-200° F	ASTM D 746
Flammability	Self-extinguishing	ASTM D 635
Tensile strength, yield	8,500 PSI	ASTM D 638
Elongation at yield	5.5-8.5%	ASTM D 638
Shear strength, yield	5,500 PSI min.	ASTM D 732
Izod impact strength (notched, 1/8" thick)	12-16 ft-lb/in.	ASTM D 256
Fatigue strength (at 2.5 mm cycles)	950 PSI min.	ASTM D 671

(c) Glass. The polycarbonate must be glass impregnated between 30% and 40% to increase strength.

POSITIONING DEVICE

4. The top and bottom opening of the bracket must have integral serrated bosses that will provide positive positioning of the signal head in five degree increments to eliminate undesirable rotation or misalignment of the signal head between sections. A total of 72 teeth must be provided in the serrated bosses to allow the signal head to be rotated 360 degrees about its axis. The teeth must be clean and sharp to provide positive positioning with the grooves of the signal head.

HARDWARE

5. The mounting brackets must be provided complete with one (1) polycarbonate shim, 1/4" thick, one (1) 1-1/2" chase nipple with rubber

gasket, and one (1) pinnacle cap with rubber gasket.

DIMENSIONS

6. The bracket must have nominal dimensions of 12 inches long, by 6 inches high, by 3 inches wide, plus or minus 1/4 inch.

WIRING SPACE

7. The bracket must have an integral molded wireway with a minimum 1-1/2 inch diameter opening suitable for installation of multi-conductor cables.

DESIGN STRENGTH

8. The bracket must be designed to support a 12 inch, single face, five-section, polycarbonate signal head with a 100 mile-per-hour wind.

TESTING AND DOCUMENTATION REQUIREMENTS

9. (a) Documentation. The contractor must provide certified manufacturing and testing documentation to demonstrate that the brackets being supplied meet or exceed the specification requirements.

(b) Inspection. The brackets will be subject to inspection at the discretion of the Commissioner. Final inspection must be made at point of delivery. Any bracket rejected must be removed and disposed of by the contractor at his sole cost.

PACKING

10. (a) Each bracket must be packed in a suitable carton so secured that the bracket will not be damaged during shipment, handling, or storage.

(b) Marking. Each carton containing brackets must be clearly marked on the outside in letters not less than three-eighths inch (3/8") tall with the legend: "POLYCARBONATE SIGNAL BRACKET, SIDE OF POLE" the appropriate City Commodity Code Number, the name of the manufacturer, the date of manufacture, and the pertinent contract number.

ELECTRICAL SPECIFICATION 1528
DIVISION OF ELECTRICAL OPERATIONS
DEPARTMENT OF TRANSPORTATION
CITY OF CHICAGO
REVISED MAY 1, 2004

PRECAST CONCRETE STRUCTURES

SUBJECT

1. This specification covers the requirements for precast concrete structures to be used as City of Chicago electrical facilities. The structures will include manholes, handholes, and street light pole foundations.

GENERAL

2. (a) Specifications. The precast structures must conform in detail to the requirements herein stated and to the Specifications and Methods of test of the American Society for Testing and Materials cited by ASTM Designation Number of which the most recently published revision will govern.

(b) Acceptance. Precast structures not conforming to this specification will not be accepted. The Commissioner of Transportation or his representative will be the sole judge in determining if the precast structures meet this specification. The Commissioner's decision will be final.

(c) Drawings. The drawings mentioned herein are drawings of the Department of Transportation. They are integral parts of this specification cooperating to state necessary requirements.

(d) Bidders Drawings. Bidders must submit with their bids detailed scale drawings of the precast structures showing actual dimensions and details. Shop drawings must be original engineering drawings created by the manufacturer. The drawings must give every dimension necessary and show how the structure is assembled.

(e) Sample. One complete precast structure of each item must be submitted within fifteen (15) business days upon request of the Chief Procurement Officer.

(f) Warranty. The manufacturer must warrant the performance and construction of the precast structures to meet the requirements of this specification and

must warrant all parts, components, and appurtenances against defects due to design, workmanship, or material developing within a period of one (1) year after the precast structures have been delivered. This will be interpreted particularly to mean structural failure of any element. The warranty must be furnished in writing guaranteeing material replacement including shipment, free of charge to the City. The Commissioner will be the sole judge in determining which replacements are to be made. The Commissioner's decision will be final.

DESIGN

3. (a) Material. Concrete must be Portland cement concrete, Class SI or PC, meeting current IDOT specifications. Pulling irons in manholes must meet or exceed the requirements of ASTM A36 steel. Pulling irons must be hot dipped galvanized. Steel reinforcing bars must meet or exceed the requirements of ASTM A615, Grade 60. Cable supports in manholes, including stanchions and racks, must be manufactured for that specific purpose. Stanchions must be non-metallic and must be capable of accommodating several different sizes of cable hooks at various elevations. A minimum of eight cable hooks, 4 inches in length, must be provided with each manhole, and should include any hardware necessary to affix the hooks to the racks. Cable hooks for handholes must be manufactured for that specific purpose. Cable hooks for handholes must be a minimum of 3 inches in length and 3 inches in depth. Anchor rods in foundations must meet the latest Electrical Material Specification 1467. Conduit elbows in foundations must meet the latest Electrical Material Specification 1462.

Foundations must include conduit elbows, anchor rods, washers, and nuts. Handholes must include cable hooks. Manholes must include cable racks, pulling irons, and cable hooks. Frames and covers, sump grates, clay tile, and ground rods are not included under this specification.

(b) Dimensions. Each manhole, handhole, and foundation must be dimensioned as shown on the appropriate standard drawing. The 30 inch diameter handhole is Standard Drawing 867. The 36 inch diameter handhole for 24 inch frame and cover is Standard Drawing 866. The 36 inch diameter for 30 inch for frame and cover is Standard Drawing 871. The 3 foot by 4 foot by 4 foot manhole for a 24 inch diameter frame and cover is Standard Drawing 730. The 3 foot by 4 foot by 4 foot manhole for 30 inch frame and cover is Standard Drawing 729. The 4 foot by 6 foot by 6 foot manhole for 24 inch frame and cover is Standard Drawing 732. The four foot by 6 foot by 6 foot manhole for 30 inch frame and cover is Standard Drawing 733. The 5 foot 4 inch by 7 foot 4 inch manhole roof is Standard Drawing 733. The precast 5 foot foundation is Standard Drawing 565.

(c) Construction. Each manhole and each handhole must have lifting anchors cast in the concrete to facilitate shipment and installation. If the manhole or handhole is in more than one piece, instructions for assembly must be provided. Also, a sufficient amount of bonding agent must be provided. The bonding agent must be approved material.

DELIVERY

4. All manholes, handholes, and foundations will be delivered to the Division of Electrical Operations storage yard at 4101 South Cicero Avenue in Chicago, or to another location within the City as indicated on the order. Any manhole, handhole, or foundation deemed to be defective by the Commissioner or his representative must be removed and replaced at no cost to the City. The Commissioner's decision will be final.

SPECIFICATION 1533
BUREAU OF ELECTRICITY
DEPARTMENT OF STREETS AND SANITATION CITY OF CHICAGO
AUGUST 8, 2006

NON-METALLIC CONDUIT

SCOPE

1. This specification states the requirements for both rigid and coilable non-metallic conduit. The conduit will be used for low voltage (600 volt rated cables) electrical street lighting and traffic control systems. It may also be used for fiber-optic communications cables. This conduit will be installed underground. Rigid non-metallic conduit may be installed on structure.

GENERAL

2. (a) Standards. The following standards are referenced herein.

ASTM – American Society for Testing and Materials
NEC – National Electrical Code
NEMA – National Electrical Manufacturer's Association
UL – Underwriter's Laboratories

(b) Warranty. The manufacturer must warrant the conduit against defective workmanship and material for a period of one year from date of installation or date of delivery. Any conduit that is found to be defective must be replaced without cost to the City.

(c) Sample. If requested by the Chief Procurement Officer, a sample of the conduit intended to be furnished under this specification, must be submitted to the Engineer of Electricity within fifteen (15) business days upon receipt of such request.

MATERIAL

2. (a) Rigid non-metallic conduit will be made of polyvinyl chloride (PVC). All conduit and fittings must comply with ASTM D 1784 and with the applicable sections of NEMA TC2, UL standard 651, and NEC Article 347. Fittings must meet the standards of NEMA TC3 and TC6, as well as UL 514.

(b) Coilable non-metallic conduit will be made of high density polyethylene (HDPE). All conduit must comply with ASTM D3485, ASTM D 1248, and

NEMA TC7.

SIZES

3. (a) PVC and HDPE will come in two wall thicknesses; schedule 40 and schedule 80.

(b) PVC will come in ten foot sections. HDPE will come on reels.

(c) Nominal inside diameters (in inches) for non-metallic conduits will include the following: ½ , ¾ , 1, 1 ¼, 1 ½ , 2, 2 ½ , 3, 3 ½, 4.

PACKING

4. Rigid conduit must be shipped in bundles. Coilable conduit must come on wooden reels. Both bundles and reels must be tagged to indicate the size and diameter of the conduit, the quantity in feet, the weight, and the manufacturer's name. The conduit itself must be marked to indicate the type and size, as well as the manufacturer.

THIS SPECIFICATION MUST NOT BE ALTERED

SPECIFICATION 1534
BUREAU OF ELECTRICITY
DEPARTMENT OF STREETS AND SANITATION CITY OF CHICAGO
SEPTEMBER 25, 2006

CABLE: SINGLE-CONDUCTOR, COPPER 600 VOLT

SUBJECT

1. This specification states the requirements for cables intended to be used as conductors in 120/240 VAC, 60 cycle, single phase, street lighting circuits. The cables will be installed in underground ducts or conduit.

GENERAL

2. (a) Specifications. The cable must conform in detail to the requirements herein stated, and to the applicable portions of the latest revisions of the specifications and methods of test of the following agencies:

(1) ICEA Specification S-95-658
(2) IEEE Standard 383
(3) ASTM Standard E662-06
(4) ASTM Standard D470-05
(5) U.L. 44
(6) U.L. 854

(b) Acceptance. Cable not in accordance with this specification will not be accepted.

(c) Sample. If requested by the Chief Procurement Officer, a three (3) foot sample of the cable intended to be provided under this specification must be sent to the attention of the Engineer of Electricity within fifteen (15) days of receipt of such request.

(d) Warranty. The manufacturer must warrant the cable to be first class material throughout. In lieu of other claims against them, if the cables are installed within twelve (12) months of date of shipment, the manufacturer must replace any cable failing during normal and proper use within two years of date of installation. All replacements under this warranty must be made free of charge F.O.B. delivery point of the original contract.

CONSTRUCTION

3. This cable must consist of a round copper conductor with a tight fitting, free stripping, concentric layer of ethylene propylene (EPR) insulation and a concentric low lead chlorosulfonated polyethylene (CSPE) jacket extruded in tandem with, and bonded to, the insulation, or ethylene propylene (EPR) insulation only. The cable must be rated for continuous duty in wet or dry conditions at 90º C operating temperature, 130º C emergency overload temperature and 250º C short circuit temperature.

CONDUCTOR

4. (a) Material. The conductor must either be soft or annealed round copper wire.

(b) Specifications. The conductor must meet the requirements of ASTM B3, B8 or B258, as applicable.

(c) Sizes. The conductor size must be as stated in the PROPOSAL and in accordance with all requirements in Table A of this specification.

(d) Stranding. The number of strands, must be as indicted in Table A. Stranding must meet the requirements of ASTM B8, Class B.

INSULATION

5. (a) Type. The insulation must be ethylene propylene rubber compound meeting the physical and electrical requirements specified herein.

(b) Thickness. The insulation must be circular in cross-section, concentric to the conductor, and must have an average thickness not less than that set forth in Table A of this specification, and a spot thickness not less than ninety percent (90%) of the average thickness.

(c) Initial Physical Requirements:

1. Tensile strength, min., psi. 1,200

2. Elongation at rupture, min. % 250

(d) Air Oven Exposure Test. After conditioning in an air oven at 121 +/- 1ºC for 168 hours using methods of test described in ASTM-D 573:

Tensile strength, minimum percent of unaged value.....75

Elongation at rupture, minimum percent of unaged value.....75

(e) Mechanicl Water Absorption:

GRAVIMETRIC METHOD: After 168 hours in water at 70+/- 1°C: water absorption, maximum, milligrams per square inch…….5

(f) Cold Bend Test Requirements. The completed cable must pass the "Cold-Bend, Long-Time Voltage Test on Short Specimens" of ASTM D-470 except that the test temperature must be minus (-) 25°C.

(g) Electrical Requirements

1. Voltage Test. The completed cable must meet an A.C. and D.C. voltage test in accordance with ASTM D-470 and D-2655.

2. Insulation Resistance. The completed cable must have an insulation resistance constant of not less than 20,000 when tested in accordance with methods shown in ASTM D-470.

JACKET

6. (a) Type. If the cable is jacketed, the jacket must be a chlorosulfonated polyethylene (CSPE) compound meeting the physical and electrical requirements specified herein. The CSPE jacket must meet CFR Title 40, Part 261, for leachable lead.

(b) Thickness. The jacket must be circular in cross-section, concentric with the insulation, must have an average thickness not less than that set forth in Table A of this specification and a spot thickness not less than ninety percent (90%) of the average thickness.

(c) Initial Physical Requirements:

1.	Tensile strength minimum PSI	1800
2.	Elongation at rupture, minimum percent	300

(d) Air Oven Exposure Test. After conditioning in an air oven at 121 +/- 1°C for 168 hours:

1.	Tensile strength, minimum percent of unaged value	75
2.	Elongation at rupture, minimum percent of unaged value	60

(e) Mechanical Water Absorption. After 168 hours at 70 +/- 1°C:

1. Milligrams per square inch, maximum 20

TESTING

7. (a) General. Tests must be performed on insulation, jacket and completed cables in accordance with applicable standards as listed in these specifications. Where standards are at variance with each other or with other portions of this specification, the most stringent requirements, as determined by an engineer from the Bureau of Electricity, will apply. All tests must be conducted on cable produced for this order. Where cable insulation and/or jacket thickness preclude obtaining samples of sufficient size for testing, special arrangements must be made with the engineer to obtain samples of unprocessed materials directly from the extrusion feed bins which will be separately processed and prepared for tests.

(b) Number Of Tests. Insulation and jacket tests must be conducted on samples taken every 25,000 feet or fraction thereof of each conductor size. In no case must samples be taken closer than 15,000 feet apart.

(c) Witness Tests. Where the quantity of cable on a single purchase order is 250,000 feet or more, all insulation and jacket tests must be witnessed by an engineer from the Bureau of Electricity, if so requested by the City. Included in these tests will be a 70,000 BTU per hour flame test in accordance with IEEE 383. Reels to be tested will be selected at random. The contractor must include in his bid, the cost of travel, food and lodging for one (1) engineer. Travel for 150 miles or greater must utilize a major airline. Lodging accommodations must be equal to those provided at a Holiday Inn. The engineer must be given ten (10) working days notice of all travel arrangements.

(d) Test Reports. No cable may be shipped until certified copies of all factory tests, including witness tests where applicable, have been reviewed and approved by the engineer.

(e) Acceptance. Samples must be taken from each reel and must successfully conform to all tests specified herein. Reels from which samples fail to conform, will be rejected.

PACKAGING

8. (a) Cable Marking. The cable must be identified by a permanently inscribed legend in white lettering as follows:

1/c No. (conductor size) AWG-600V-90°C-EPR or EPR/CSPE

The legend must be repeated at approximately eighteen (18) inch intervals on the outside surface of the cable parallel to the longitudinal axis of the conductor. A sequential footage marking must be located on the opposite side from the legend.

(b) All cable will be black pigmented. When three conductors (triplex) are specified, one conductor will be black, another will be red or black with a red tracer, the smaller of the conductors must have a green colored jacket and the three conductors must be triplexed with a 16"-18" lay. The insulation color must not be unduly affected by cable installation, or prolonged exposure to either direct sunlight or moisture. Where the quantity of triplex cable exceeds 80,000 feet, witness testing as outlined in section 7(c) will apply.

(c) Reels. The completed cable must be delivered on sound substantial, non-returnable reels. Both ends of each length of cable must be properly sealed against the entrance of moisture and other foreign matter by the use of clamp-on cable caps, such as the Reliable Electric Company neoprene cable cap No. 1405, or equal. The ends must be securely fastened so as not to become loose in transit. Before shipment, all reels must be wrapped with cardboard or other approved wrapping.

(d) Footage. Each reel must contain the length of cable as set forth in Table A of this specification. Alternate lengths may be considered.

(e) Reel Marking. A metal tag must be securely attached to each reel indicating the reel number, contract number, date of shipment, gross and tare weights, description of the cable, the total footage, and the beginning and ending sequential footage numbers. Directions for unrolling the cable must be placed on the reel with an approved permanent marking material such as oil-based paint or a securely attached metal tag.

TABLE "A"

CONDUCTOR		INSULATION/JACKET THICKNESS		A-C TEST	REEL LENGTH
AWG	STRANDS	MILS	MILS	VOLTS	FEET
14	7	30	15	5500	2000
8	7	45	15	5500	2000
6	7	45	30	5500	2000
4	7	45	30	5500	2000
2	7	45	30	5500	1000
0	19	55	45	7000	1000
00	19	55	45	7000	1000
000	19	55	45	7000	1000
0000	19	55	45	7000	1000
250 MCM	37	65	65	8000	1000

THIS SPECIFCATION MUST NOT BE ALTERED

ELECTRICAL SPECIFICATION 1545
DIVISION OF ELECTRICAL OPERATIONS
DEPARTMENT OF TRANSPORTATION
CITY OF CHICAGO
REVISED JANUARY 28, 2010

PEDESTRIAN COUNTDOWN TRAFFIC SIGNAL LED, 16 INCH WITH SYMBOLIC WALK/DON'T WALK LENSES

SUBJECT

1. This specification states the requirements for a single section pedestrian countdown signal with light emitting diode (LED) symbolic messages on nominal sixteen inch by eighteen inch lenses and enclosed in a polycarbonate housing.

GENERAL REQUIREMENTS

2. (a) Sample and Certified Test Reports. One complete pedestrian countdown signal, fully assembled and wired, of the manufacture proposed to be furnished, must be submitted along with the required certified test reports, within fifteen (15) business days upon request of the Chief Procurement Officer. The sample must be delivered to the Division of Electrical Operations, 2451 South Ashland Avenue, Chicago, Illinois 60608.

(b) Standards. Equipment furnished under this specification shall meet the appropriate requirements of the following standards, as required within the body of this specification:

American Association of State Highway and Transportation Officials (AASHTO)
American Society for Testing and Materials (ASTM)
Institute of Transportation Engineers (ITE)
National Electrical Manufacturers Association (NEMA)
Underwriters Laboratories (UL)

(c) Approval. Approval will mean approval in writing by the Commissioner or his duly authorized representative.

(d) Location. The supplier of the LED modules shall actively maintain an office,

stocking warehouse, and technical support within a 100 mile radius of the City of Chicago.

MATERIAL AND EQUIPMENT REQUIREMENTS

3. (a) The pedestrian signal heads must conform to ITE Standard "Pedestrian Traffic Control Signal Indications" (PTCSI), in which the most recently published revision will govern.

(b) Housing Design. The housing must be one piece, ultra violet stabilized polycarbonate resin of the specified color, injection molded complete with integral top, bottom, and sides, having a minimum thickness of 0.100 inches.

The polycarbonate formulation used must provide these physical properties in the housing (Tests may be performed on separately molded specimens).

TEST	REQUIRED	METHOD
Specific gravity	1.17 minimum	ASTM D 792
Vicat Softening temp	310-320° F	ASTM D 1525
Brittleness temp.	Below-200° F	ASTM D 746
Flammability	Self-extinguishing	ASTM D 635
Tensile strength, yield	8,500 PSI	ASTM D 638
Elongation at yield	5.5-8.5%	ASTM D 638
Shear strength, yield	5,500 PSI min.	ASTM D 732
Izod impact strength (notched, 1/8" thick)	12-16 ft. lbs./in.	ASTM D 256
Fatigue strength (at 2.5 mm cycles)	950 PSI min.	ASTM D 671

(c) Positioning Device. The top and bottom opening of each housing must have integral serrated bosses that will provide positive positioning of the signal head in five degree increments to eliminate undesirable rotation or misalignment of the signal head between sections. A total of 72 teeth must be provided in the serrated bosses to allow the signal face to be rotated 360 degrees about its axis. The teeth shall be clean and sharp to provide positive positioning with the grooves of the mating section or framework. Each opening must accommodate standard 1 2" pipe fittings and brackets.

(d) Hinges. The housing must have four integral hinge lugs, with stainless steel hinge pins (AISI 304 or equivalent), located on the left side for mounting the door. The hinge pins must be straight and not protrude past the outside of the housing lugs. The housing must have two integral latching bolt lugs on the right side each with a stainless steel hinge pin to which a latching bolt (AISI 304 or equivalent), washer, and wing nut will be attached. The wing nuts must be captive.

(e) Door. The door must be a one piece ultraviolet stabilized polycarbonate resin of the specified color, injection molded complete with a minimum thickness of 0.1 inch. Two (2) hinge lugs on the left side and two (2)sets of latch screw jaws centered on the right side, as viewed from the front of the signal, must be integrally cast with the housing door. The door must be hinged to the housing with two (2) stainless steel hinge pins, drive fitted. Two (2) stainless steel latch screws and wing nuts and washer assemblies on the latch side of the housing body must provide for opening and closing the door without the use of tools. The door must have four (4) holes with threaded metal inserts for stainless steel machine screws to secure the lens.

The inside of the door must be grooved to accommodate a one piece, air-cored EPDM (ethylene propylene diene monomer) gasket to provide a weatherproof and dust proof seal when the door is closed. The inside of the door must have four equally spaced threaded metal inserts for the lens attachment. The outside of the door must have an integral rim completely encircling the lens opening to prevent leakage between the door and the lens. The rim must have equally spaced tabs around the circumference with threaded metal inserts a the visor attachment.

(f) Gaskets. Wherever necessary to make a completely dust-proof, moisture-proof and weatherproof assembly of the housing and optical system, approved type gaskets of neoprene or silicone rubber shall be provided.

LED OPTICAL UNITS

4. (a) Light emitting diode (LED) optical unit must consist of an integral unit containing the following components: power leads, housing, integral lens, matrix of light emitting diodes (LEDs) emitting monochromatic light of desired colors, and electronic and electrical components necessary to permit operation at nominal 120 volt, 60 hertz power. All units shall form a neat compact unit within the housing body with no light leakage between the door and the housing body.

(b) The LED unit shall meet the applicable requirements of ITE standards for color (chromaticity) and brightness (luminance). During the required operating life of LED signal units, the luminance output of the units must not be less than 60 percent (.60) of the values specified in the standard.

(c) Unit power supply must be constant current regulated and filtered to provide instant on indications, and to prevent momentary signal outages or flicker.

(d) Units shall consist of LEDs uniformly distributed to present a homogeneous appearance on the face of the lens from a wide viewing angle.

(e) LEDs shall be wired so that the loss of a single LED or a string of LEDs will not reduce the luminescence below the minimum requirement.

(f) For purposes of this specification, failure of a single unit is defined as an occurrence where the luminescence of the signal measured in candela in standard test procedures is less than the required initial luminance or luminance at time points and conditions specified; or where minimum required brightness is achieved, but two or more series strings of LEDs or in excess of twenty percent of 20% of LEDs are not operable.

(g) Units must be fully operable over a range of 90 volts to 130 volts at 60 hertz, plus or minus 3 hertz.

(h) Surge protection. Each unit must be provided with integral surge protection to withstand transient of 600 volt, 100 microsecond rise and 1 millisecond pulse width. The surge protector shall provide full electrical and physical protection to all unit components.

(i) Maximum permissible power consumption at ambient conditions (nominal 120 volts, 60 hertz, 70 degrees F.) must be 18 watts at a minimum 90 percent power factor. Power consumed must not vary by more than ten (10) percent from nominal power consumption over voltage range of 105 volts to 125 volts, and over permissible environmental ranges.

(j) Units must be fully operable at temperature ranges of -40 degrees F. (-40 deg C) to +165 degrees F. (+74 deg C) at up to 100 percent relative humidity.

(k) Units shall be clearly marked on the back surface of the unit in a permanent manner showing information required for warranty and long term performance. Information to be shown must include manufacturer name, date of manufacture, electric power requirements, signal model type, and signal serial number.

(l) The LED unit shall be compatible with all traffic signal controller equipment currently in use by the City of Chicago, and meeting the City's latest specifications for traffic signal control equipment. In particular the LED unit shall be compatible with the NEMA TS-1 and later traffic signal load switches and conflict monitors.

(m) Units shall meet applicable sections of Title 47, SubPart B, Section 15 of the Federal Communications Commission (FCC) rules as applies to electronic noise limitation and electromagnetic interference.

(n) Total harmonic distortion (THD) induced into the voltage and current AC power line sine waves must not exceed 20 percent.

(o) Burn-in. LED Optical units must be energized for a minimum 24 hour burn-in at 100% on-time duty cycle.

DISPLAY

5. (a) The message area shall be approximately 16 inches square and display the double overlay "Don't Walk" and "Walk" symbols immediately adjacent to the countdown digits. The symbols shall be applied in such a manner as to provide an opaque polycarbonate background and illuminated legends.

(b) Symbolic Messages. Symbols for "Walk" (Man) and "Don't Walk" (Hand) must conform in style and color to those of ITE. The symbols must be not less than nine and one-half inches (9 2") tall with proportional width. The "Don't Walk" symbol must be Portland Orange, and the "Walk" symbol must be of lunar white, conforming to the specifications of the ITE/PTCSI.

(c) Countdown Digits. Countdown digits must be Portland Orange and not less 9" high with proportional width and shall be compliant with latest ITE standards.

(d) Lens. The unit lenses must be constructed of ultraviolet (UV) stabilized , impact resistant polycarbonate, acrylic or other approved material. Lenses must be anti-glare, smooth texture, and clear.

WIRING

6. (a) Wire Leads. Each lamp connector must be furnished with three (3) leads color coded as follows:

White	-	Common
Red	-	"Don't Walk" Indication
Green	-	"Walk" Indication

The leads must be TEW, number 18 AWG, stranded copper wire with 2/64 inch thick, 600 volt, 105 degree C, thermoplastic insulation meeting MIL-W-76Aspecifications. The ends of the lamp leads must be stripped of one-half inch (2") of insulation and tinned. The leads must be splice-free and connected to one side of the terminal strip.

(b) Terminal Strip. A four terminal, eight point, barrier type terminal strip with solid base and pressure plate type connectors must be securely attached at each end to the housing body inside the walk section.

(c) Cable. One eleven foot (11') length of flexible electric cord, medium duty,

type SO, 3-conductor No. 16 AWG stranded copper, color coded, rubber insulated, neoprene jacketed, must be furnished with each pedestrian signal. Both ends of each cable length must be carefully stripped of six inches (6") of jacket and one inch (1") of insulation, and each conductor properly tinned.

COUNTDOWN FUNCTIONALITY

7. (a) The countdown module shall be compatible with all traffic signal controller equipment currently in use by the City of Chicago, and meeting the City's latest specifications for traffic signal control equipment.

(b) The countdown timer must have a micro-processor capable of recording its own time when connected to a traffic controller.

(c) The countdown timer module must continuously monitor the traffic controller for any changes to the pedestrian phase time and re-program itself automatically as needed.

(d) The countdown module must register the time for the walk and clearance intervals individually and must begin counting down at the beginning of the pedestrian change interval (flashing hand).

(e) At the end of the pedestrian change interval, the module must display A0" and the blank out. The display must remain dark until the beginning of the next countdown.

(f) In the event of a preemption sequence, the countdown module must skip the pre-empted clearance time and reach "0" at the end of the pedestrian change interval.

(g) The countdown must remain synchronized with signal indications and always reach A0" at the end of the pedestrian change interval.

(h) The countdown must not display an erroneous or conflicting time when subjected to defective load switches.

TESTING AND DOCUMENTATION REQUIREMENTS

8. (a) Documentation. The contractor shall provide certified manufacturing and testing documentation to demonstrate that the traffic signals being supplied meet or exceed the specification requirements. All LED Optical Units shall be tested by a nationally recognized testing laboratory (NRTL), such as Intertek (ETL), to demonstrate compliance with the latest ITE VTCSH specification. All LED units shall have the testing laboratory's label attached.

(b) Inspection. The signals will be subject to inspection at the discretion of the Commissioner. Final inspection shall be made at point of delivery. Any signal rejected must be removed and disposed of by the contractor at his sole cost.

(c) Warranty. The manufacturer shall warrant the signals to meet the requirements of this specification, and must warrant all equipment, components, parts and appurtenances against defective design, material and workmanship for a period of three (3) years from date of acceptance. In addition, LED optical units must carry a seven (7) year warranty against failure or loss of color (chromicity) and signal brightness (luminance) below minimum acceptable PTCSI standard levels from date of final acceptance for contract construction, or date of delivery on a specific order. In the event defects and failures occur in the LED units during the warranty period, the manufacturer must replace such units at no expense to the City. This warranty shall be evidenced by a letter or certificate of warranty submitted to the City at the time delivery is made. The LED warranty must cover all units delivered in an order or installed by contract, and must include unit serial numbers. The warranty must be signed and dated by an official of the manufacturer who is empowered by the manufacturer to enter into such a warranty.

PACKAGING

9. (a) Packing. Each pedestrian signal assembly shall be packed in a suitable carton so secured that the signal will not be damaged during shipment, handling or storage.

(b) Marking. Each carton containing a pedestrian signal shall be clearly marked on the outside in letters not less than three-eighths (3/8) inch tall with the legend: "PEDESTRIAN SIGNAL, COUNTDOWN, SIXTEEN-INCH, SYMBOLIC LED WALK-DON'T WALK@, the name of the manufacturer, the date of manufacture, the pertinent Contract Number and the appropriate City Commodity Code Number.

ELECTRICAL SPECIFICATION 1560
DIVISION OF ELECTRICAL OPERATIONS
DEPARTMENT OF TRANSPORTATION
CITY OF CHICAGO
REVISED JUNE 1, 2009

ADVANCED TRANSPORTATION CONTROLLER AND CABINET WITH UNINTERRUPTIBLE POWER SUPPLY

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1. GENERAL REQUIREMENTS

1.1 This specification details the requirements for traffic signal control equipment for use in the City of Chicago. This equipment will control traffic signal timing and sequencing at an intersection. The equipment will include a battery back-up system which will maintain power to the signals during a power failure.

1.2 If requested by the Chief Procurement Officer, within sixty (60) business days from receipt of notice, the contractor must provide a sample to the Division of Electrical Operations, 2451 South Ashland Avenue, Chicago, Illinois 60608. The sample must consist of the controller, cabinet, load switches, conflict monitor, batteries, and all appurtenant wiring and equipment completely assembled as a working unit. This sample must be regarded as a finished production sample and conformance or non-conformance to these specifications must be based on the sample submitted. No subsequent modifications to the production sample will be allowed. The sample must become the property of the City of Chicago with a suitable credit issued to the contract.

1.3 All tests as outlined herein must be regarded as minimum requirements. The contractor must submit his testing procedure for approval prior to performing any testing functions. Upon successful completion of all testing, certified test reports must be submitted for each unit. Units not successfully passing these tests or lacking proper documentation will be rejected. The manufacturer, or manufacturer's representative, must be available for shop testing at the City's facilities any equipment designed for railroad preemption for specific sites.

1.4 Standards. Equipment furnished under this specification must meet the appropriate requirements of the following standards, as required within the body of this specification:

American Association of State Highway and Transportation Officials (AASTHO)
American Society for Testing and Materials (ASTM)

Institute of Transportation Engineers (ITE)
Manual on Uniform Traffic Control Devices (MUTCD)
National Electrical Manufacturers Association (NEMA)
Occupational Safety and Health Administration (OSHA)
Underwriters Laboratories (UL)

1.5 Standard Drawings. The Electrical Standard Drawing 962 "Load Switch and Conflict Assignment", Electrical Standard Drawing 964 "Traffic Controller Cabinet Back Panel and Power Supply, 1 of 2", and Electrical Standard Drawing 965 "Traffic Controller Cabinet Back Panel and Power Supply, 2 of 2" are integral parts of this specification.

1.6 Warranty. The manufacturer(s) must warranty the performance and construction of the traffic signal controller and other major components to meet the requirements of this specification, and must warranty all parts, components, and appurtenances against defects in design, material, and workmanship for a period of one (1) year after installation on moving parts, and for a period of five (5) years after installation on solid state devices. In the event of defects or failures during these periods, the manufacturer(s) must repair and/or replace all defective or failed parts or appurtenances at no expense to the City.

1.7 Manufacturer. The manufacturer of the controller and the manufacturer of the battery back-up system must demonstrate a knowledge of past production, or have been actively engaged in the sale and/or service of the equipment herein described, as demonstrated by a submitted list of comparable projects.

2. CONTROLLER REQUIREMENTS

2.1 ATC. The controller must be an Advanced Transportation Controller (ATC) meeting the requirements of the specification "Advanced Transportation Controller (ATC) Standard Version 5.2b" dated June 26, 2006. The referenced specification is a joint effort of AASTHO, NEMA, and ITE. Since each user agency has different controller needs, for the City of Chicago the controller must meet the programming modifications and options listed in the ATC Matrix as indicated in Table A. All software necessary to make the controller operational must be included.

2.2 Power. The controller must operate on 120 volt, 60 cycle (± 3 Hertz), single phase, alternating current. The controller must function in the range from 95 to 135 Volts a.c. The power consumed must be under 50VA.

2.3 Packing. Each controller, with all its component parts, must be suitably packed in a single container in such a manner as to prevent damage to the contents in shipment and handling.

2.4 Instructions. One (1) complete set of up to date instructions providing complete

information on installation, adjustment, operation and maintenance, including both up to date "Logic Schematics" and "Electronic Circuit" diagrams, of these controllers, must be furnished to the Division of Electrical Operations for approval prior to the first shipment of controllers. All information, including photos and schematics, must reference to the controller being furnished on this contract and must be a high quality, completely legible reproduction. Upon approval, one complete set of data must be furnished with each controller.

2.5 Training. The contractor must provide training at the City's facilities. The training must be on the actual equipment provided under the contract, and must include, but not be limited to, programming all features, connecting and wiring, and troubleshooting. Training manuals are required (training manuals should include the instructions in a teaching-type format). Training for up to five (5) City personnel is required.

2.6 Chassis. Aluminum construction with powder coat finish. No plastic chassis or composite chassis will be allowed. The controller must physically fit into existing 'M', 'P', and 'SUPER P' cabinets configured for City of Chicago applications, so that retrofitting will not be a problem. The controller must not exceed the following dimensions: 10.5 inches high, 10.5 inches deep, and 15 inches wide.

2.7 Processor / Memory. At a minimum, the processor will be:

Clock speed - 300MHz
Non-volatile Memory - 16MB Flash
RAM - 16MB
SRAM - 1MB
(All memory and firmware must be stored in flash memory. No EPROMS will be allowed.)

2.8 Display. 16 x 40 backlit LCD using a 6 x 8 character font. Display and keypad must be permanently attached to chassis. Detachable keypads will not be allowed.

2.9 Environmental. The controller must operate in the temperature range of -34 degrees Celsius to +74 degrees Celsius. The controller must operate within the relative humidity of 5% to 95%.

2.10 All printed circuit boards must be mounted vertically.

2.11 Encapsulation of 2 or more discrete components into circuit modules is prohibited except for transient suppression circuits, resistor networks, diode arrays, solid-state switches, optical isolators and transistor arrays. All encapsulated components must be second sourced and must be of such design, fabrication, nomenclature or other identification as to be purchased from a

wholesale distributor or from the component's manufacturer as a standard product. Custom encapsulated components are not allowed.

2.12 Obsolete components, components no longer supported by the manufacturer, components not recommended for new designs, components which have been discontinued or which the CONTRACTOR should have reasonably been expected to know were discontinued, or components which the vendor/manufacturer has announced plans to discontinue at the time of the bid must not be used in the design of any subassemblies provided under this contract.

2.13 The controller must meet the functional and environmental requirements of NEMA TS2 2003. The use of 2070s, 170s, BIUs, SIUs, or similar devices is not allowed.

2.14 As allowed by ATC v5.2b, Section 8.1.1, the controller will utilize NEMA 'A', 'B', and 'C' I/O connectors, except for the HMC-1000 and LMD40 I/O variants. Pin assignments for NEMA 'A','B', and 'C' connectors must follow the NEMA TS2 2003 standards for I/O. Port 2 must be the ATC v5.2b pin-limited version of NEMA TS2 Port 2. Port 3 must not be FSK, but should be TIA-574. Port 4 (C50S) must be a 9-pin connector with only limited signals being required.

Special function connector for the TS2-2 must follow the CPC style "D" pin outs as follows:

CPC MSD Pin	***Function***
1	Flash
2	Offset 1
3	Interconnect Common
4	User defined input 6
5	Offset 2
6	Offset 3
7	Time Plan A
8	User defined input 7
9	User defined input 8
10	Call to Free
11	Call to week 10
12	Time Plan B
13	Time Plan C
14	Time Plan D
15	Alt Seq A
16	Alt Seq B
17	Alt Seq C
18	Dimming

19	Monitor status bit C
20	System Input
21	Alt Seq D
22	Monitor status bit A
23	Monitor status bit B
24	Veh Det 13
25	Veh Det 9
26	Veh Det 10
27	Veh Det 11
28	Polarizing Pin
29	Veh Det 12
30	Veh Det 14
31	Veh Det 15
32	Veh Det 16
33	SGO/Conditional Service
34	Preempt input 5
35	Preempt output 1
36	Preempt output 2
37	Interconnect inhibit
38	Time Clock sync
39	Sync inhibit
40	Preempt input 1
41	Preempt input 2
42	Preempt input 3
43	Preempt output 3
44	Polarizing Pin
45	Preempt output 4
46	Preempt output 5
47	System Out
48	Preempt output 6
49	Preempt input 4
50	Clock Ckt 9 (Aux 1)
51	Clock Ckt 10 (Aux 2)
52	Clock Ckt 11 (Aux 3)
53	Clock Ckt 12 (Aux 4)
54	Clock Ckt 13 (System)
55	Clock Ckt 8 (Flash)
56	Clock Ckt 3 (Offset 1)
57	Clock Ckt 4 (Offset 2)
58	Clock Ckt 5 (Offset 3)
59	Clock Ckt 1 (T/P A)
60	Clock Ckt 2 (T/P B)
61	Clock Ckt 6 (T/P C)
62	Clock Ckt 7 (T/P D)

63	Preempt input 6

2.15 Downward compatibility with existing City of Chicago cabinets.

(1) The controller must be of a modular design allowing for the ability to exchange I/O modules to allow for use in existing City of Chicago HMC-1000, LMD40, and standard NEMA TS2-2 cabinets. This I/O module must be "plug and play". The controller's firmware must detect the type of I/O installed (HMC-1000, LMD40 or NEMA TS2) and provide the proper user interface. Adapter harnesses for the HMC-1000, LMD40 and Setcon clock will not be allowed.

(2) The HMC-1000 I/O module must be pinned as follows:

63 Pin Connector	**Function**
1	Output 20
2	Output 11
3	Manual Advance
4	Stop Time
5	Output 24
6	Offset 1
7	Offset 3
8	Output 15
9	Preempt 2
10	Advance
11	Output 23
12	Restart
13	Output 32
14	Offset 2
15	Output 16
16	Preempt 1
17	Output 25
18	Output 28
19	Spare 1
20	Spare 2
21	Output 7
22	Output 18
23	Output 21
24	Output 22
25	Dial 3

26	Dial 2
27	Output 1
28	Output 14
29	Output 4
30	Output 29
31	Output 27
32	Output 17
33	Output 9
34	Output 19
35	Dial 4
36	On-Line
37	Flashing Bus
38	Manual
39	Output 30
40	Output 31
41	Output 12
42	Output 10
43	Output 2
44	Output 3
45	Output 13
46	Output 8
47	Output 26
48	Logic Ground
49	Not Used
50	Not Used
51	Output 5
52	Output 6
53	Logic Ground
54	Logic Ground
55	Not Used
56	Not Used
57	Not Used
58	Not Used
59	24 V.D.C
60	Not Used
61	115 Volts AC
62	AC Neutral
63	Chassis Ground

(3) The LMD40 I/O module contains 4 I/O connectors, MSA, MSB, MSD, and communications connectors which must be pinned as follows:

LMD40 MSA	**Pin**	**Voltage Level**
Actuation 3	A	DC
24 V.D.C	B	DC
Voltage Monitor	C	DC
Actuation 1	D	DC
Actuation 2	E	DC
Preemption 2	F	DC
Preemption 1	G	DC
Interval Advance	H	DC
Stop Time	J	DC
MCE (Manual Control)	K	DC
External C/S/O	L	DC
Signal Plan 2	M	DC
Signal Plan 3	N	DC
System Cont/AZ Reset	P	DC
External Start	R	DC
Remote Flash (AC)	S	120 VAC
Interconnect Common	T	120 VAC
AC – (Common)	U	AC
Chassis Ground	V	Earth Ground
Logic Ground	W	DC Reference
Output 1	X	DC
Output 2	Y	DC
Output 3	Z	DC
Output 4	a	DC
Output 5	b	DC
Output 6	c	DC
Output 7	d	DC
Output 8	e	DC
Output 9	f	DC
Output 10	g	DC
Output 11	h	DC
Output 12	i	DC
Output 13	j	DC
Output 14	k	DC

Output 15	m	DC
Output 16	n	DC
AC+ input	p	120 VAC
Output 17	q	DC
Output 18	r	DC
Output 19	s	DC
Output 20	t	DC
Output 21	u	DC
Spare Output	v	DC
Spare Output	w	DC
Spare Output	x	DC
Cycle 2 (User Defined)	y	120 VAC
Cycle 3 (User Defined)	z	120 VAC
Split 2	AA	120 VAC
Split 3	BB	120 VAC
Output 22	CC	120 VAC
Output 23	DD	120 VAC
Offset 1	EE	120 VAC
Offset 2	FF	120 VAC
Offset 3 (user def 1)	GG	120 VAC
Output 24	HH	DC

LMD40 MSB	**Pin**	**Voltage**
Output 25	A	DC
Output 26	B	DC
Output 27	C	DC
Output 28	D	DC
Output 29	E	DC
Output 30	F	DC
Output 31	G	DC
Output 32	H	DC
Output 33	J	DC
Output 34	K	DC
Output 35	L	DC
Output 36	M	DC
Output 37	N	DC
Output 38	P	DC
Output 39	R	DC
Output 40	S	DC
Actuation 4	T	DC

Hold	U	DC
Force Off	V	DC

LMD40 MSD	**Pin**	**Voltage**
Flash Monitor 1	1	120 VAC
Cycle 5	2	120 VAC
PE Clear 1	3	DC
PE Clear 3	4	DC
Flash Monitor 2	5	120 VAC
Spare Input 4	6	120 VAC
System Input	7	120 VAC
AZ Reset (Absolute Zero)	8	DC
PE Clear 2	9	DC
UD 6 Input	10	DC
Call to week 10	11	DC
Signal Plan 6	12	DC
Signal Plan 7	13	DC
Signal Plan 8	14	DC
Actuation 5	15	DC
Actuation 6	16	DC
Actuation 7	17	DC
Spare input 1	18	DC
UD 7 Input	19	DC
Actuation 8	20	DC
Actuation 9	21	DC
Actuation 10	22	DC
Spare input 2	23	DC
UD 8 input	24	DC
Sys Command (Ckt 13)	25	DC
Flash Attained	26	DC
PE Active	27	DC
Polarization	28	DC
System Out	29	DC
Preempt input 3	30	DC
Preempt input 4	31	DC
Preempt input 5	32	DC
Signal Plan 5 in	33	DC
Call to FREE op	34	DC
Output 41	35	DC
Output 42	36	DC
Interconnect Inhibit	37	DC

Spare input 3	38	DC
Sync Inhibit	39	DC
Dimming	40	DC
Added Time inhibit	41	DC
Time Clock Sync	42	DC
Output 43	43	DC
Polarization	44	DC
Output 44	45	DC
Output 45	46	DC
Output 46	47	DC
Output 47	48	DC
Signal Plan 4	49	DC
Aux 1 (Ckt 9)	50	DC
Aux 2 (Ckt 10)	51	DC
Aux 3 (Ckt 11)	52	DC
Aux 4 (Ckt 12)	53	DC
Output 48 (FF Enable)	54	DC
Flash Out (Ckt 8)	55	DC
Offset 1 (Ckt 3)	56	DC
Offset 2 (Ckt 4)	57	DC
Offset 3 (Ckt 5)	58	DC
Cycle 2 (Ckt 1)	59	DC
Cycle 3 (Ckt 2)	60	DC
Split 2 (Ckt 6)	61	DC
Split 3 (Ckt 7)	62	DC
Fast Flash Image	63	DC

LMD40 Communication Connector (15 pin sub-D	**PIN**	**Voltage**
System Detector 11	1	DC
System Detector 12	2	DC
System Detector 13	3	DC
System Detector 14	4	DC
System Detector 15	5	DC
System Detector 16	6	DC
System Detector 17	7	DC
System Detector 18	8	DC
Monitor Status bit B	9	DC
Monitor Status bit A	10	DC
Monitor Status bit C	11	DC
DC User Defined in #1	12	DC
Logic Ground	13	DC
DC User Defined in #2	14	DC

~~DC User Defined in #3~~ 15	DC	

(4) The Setcon I/O connector will be resident on the HMC1000 version of the ASTC I/O.

Setcon Clock Connector	**PIN**	**Voltage**
Output 1	1	DC
Output 2 (Dial 2)	2	DC
Output 3 (Dial 3)	3	DC
Output 4 (Dial 4)	4	DC
Output 5 (Offset 1)	5	DC
Output 6 (Offset 2)	6	DC
Output 7 (Offset 3)	7	DC
Output 8 (Flash)	8	DC
Sync Output	9	DC
Sync Input	10	DC
Not used	11	N/A
Logic Ground	12	DC
Not Used	13	N/A
Not Used	14	N/A
Not Used	15	N/A
Not Used	16	N/A

2.16 Communication.

(1) NTCIP (National Transportation Communications for ITS Protocol).

a. The controller must be compliant with NTCIP Standards as outlined in NEMA TS2 – 2003 and must be tested and documented for compliance.

b. Global objects must be compliant to NTCIP 1201 v2.26 or later.

c. Actuated Signal Controller objects must be compliant to NTCIP 1202 v2.19f or later.

(2) Serial ports, one of which must be set as either RS-232 or RS-485.

(3) Ability to add an internal GPS module.

(4) Ethernet. The controller must be equipped with a minimum of two front panel mounted 10/100Mb Ethernet ports.

(5) A single port USB interface must be provided to facilitate database transfers, re-flashing of operation software and log transfer.

(6) The unit must be fully compatible with, and fully functional within, the City's existing MIST system (Management Information System for Transportation). All available functions and capabilities that exist within existing MIST controllers must be available within this unit. Any additional software or hardware necessary to fully integrate the controller into the MIST system must be provided by the bidder and will be considered as part of the requirements of this specification.

(7) A Windows based laptop utility software must be provided for data transfers and monitoring of controller operation.

(8) A fiber-optic modem must be provided, if required. The modem must be compatible with existing City fiber interconnect systems. The modem may be internal or external to the controller.

2.17 Software operation.

(1) The controller must have the ability to re-synch a minimum of 8 cycle lengths to an "absolute zero" reference point. It must be possible to set absolute zero by either global command or individual cycle length.

(2) In addition to hardwire input, it must be possible to set Absolute Zero via keyboard command or fiber optic communication.

(3) The controller must have the ability to operate in two modes of operation, selectable by time of day:

a. Actuated control per NEMA TS2 – 2003.

b. Pretimed Interval based control per NEMA TS2 – 2003.

(4) The controller must have the ability to transfer between actuated control and interval based control by time of day schedule.

(5) The controller will have 32 Pre-timed plans

a. Each plan will allow for up to 32 timing intervals

b. Each plan will allow for 48 circuit outputs. Each output must be individually programmable per interval.

(6) The controller must have 100 coordination plans.

(7) The controller must provide 6 preempts per NEMA TS2-2003.

(8) The controller will offer security as follows:

a. Two 4 digit security codes can be programmed (one for timing data, one for signal plan data), which when activated, allow data changes. These codes must automatically de-activate 10 minutes after the last user keystroke. It will be possible to re-program the security codes if the previous security code is known or has been defeated.

b. It will not be possible to read the security code from the controller's display.

c. It will be possible to access the controller in the case of a lost security code through a "back door" which is provided only by the controller manufacturer. This "back door" security code must change based upon the controller's internal calendar.

2.18 Pre Shipment Testing. The manufacturer of the controller must perform at his manufacturing facilities a one hundred (100) hour burn-in test on every controller, conflict monitor unit, and appurtenant devices. This test period must be certified by the manufacturer with supportive documentation and must include the device serial number, dates and times of test periods, and results. Any failed, or nonconforming components must be replaced at this time. The 72 hour function test described in this specification, must be performed on each complete controller system. After each of the components has passed the burn-in test, they may be used in the assembly of the complete controller unit. Each completed unit must be subjected to the 72 hour function test as described in this specification. Should the controller fail to complete this test for any reason, the failed portion(s) of the unit must be replaced and the test repeated in its entirety. Certification of these tests must be attached to the outside of the shipping container. Any containers without this attached certification will be returned to the manufacturer at his sole expense. This certification is in addition to any other documentation and/or testing required by these specifications.

3. CONFLICT MONITOR

3.1 General. Each controller must be furnished with a NEMA conflict monitor unit for checking for conflicts in the signal output circuits. The conflict monitor must be capable of monitoring a minimum of twelve (12) distinct channels. It must be a self-contained unit with its own power supply and not be located within the timer housing.

3.2 Programming Board. A removable programming board must be supplied with

the monitor for programming signal compatibility. The circuits for programming must be composed of soldered jumper wires. Diode or dip switch type programming will not be acceptable. The programming board must contain no circuitry or components other than the wire jumpers and the wire jumper soldering devices.

3.3 Flashing Circuit Energizing. The conflict monitor must be programmed to put the controller in a flashing sequence upon detection of a failure or conflicting signal display. The controller must also be programmed to energize the flash circuit if the conflict monitor is removed or loses its supply voltage. The conflict monitor must have a manual reset button to return the controller to normal operation after conflict circuit operation is no longer necessary.

3.4 Stop Time Circuit. A stop-time control circuit must be supplied from the conflict monitor to force the timer unit to stop timing upon detection of a conflict.

3.5 Indicator. The front panel of the conflict monitor housing must have an indicator which will be activated when a conflict or failure occurs as per Section 6 of NEMA Spec. TS1-1983.

3.6 Latch Circuit. The conflict monitor must have a latch circuit, insuring that if a voltage monitor failure occurs, the intersection remains in conflict until reset.

3.7 Memory. The conflict monitor must have the ability to store, in memory, a minimum of ninety-nine (99) conflict events, including date of conflict and channels conflicting.

3.8 Conflict Monitor Assignments

(1) Conflict monitor channels must be assigned as follows:

Channel 1	Load Switch 1	Phase 1 Vehicle
Channel 2	Load Switch 2	Phase 2 Vehicle
Channel 3	Load Switch 3	Phase 3 Vehicle
Channel 4	Load Switch 4	Phase 4 Vehicle
Channel 5	Load Switch 5	Phase 5 Vehicle
Channel 6	Load Switch 6	Phase 6 Vehicle
Channel 7	Load Switch 7	Phase 7 Vehicle
Channel 8	Load Switch 8	Phase 8 Vehicle
Channel 2W	Load Switch 9	Phase 2 Ped
Channel 4W	Load Switch 10	Phase 4 Ped
Channel 6W	Load Switch 11	Phase 6 Ped
Channel 8W	Load Switch 12	Phase 8 Ped

Channel 9	Load Switch 13	Overlap A
Channel 10	Load Switch 14	Overlap B
Channel 11	Load Switch 15	Overlap C
Channel 12	Load Switch 16	Overlap D

(2) It must be possible for the user to change conflict assignments without unsoldering any connections.

(3) All unused channels - vehicle or pedestrian - must be neatly tied or terminal mounted in such a manner that they are readily available in front of the panel. If tied, the harness wires must be labeled. If terminal mounted, the terminations must be labeled.

(4) A terminal must be provided for the red enable feature.

(5) A terminal must be provided for the hook up of any unused red channels to AC.

(6) Controller monitoring must consist of; voltage monitor, 24VDC- I, 24VDC-II.

(7) The output relay must operate a sixty (60) ampere, normally open, "A" type mercury contactor without the use of an external or "cabinet interface" relay.

4. SUPER P CABINET

4.1 Housing. Each controller must be furnished completely housed in a Type 5052-H32 aluminum housing of 0.125 inch thickness. The exterior dimensions of the cabinet must be 57 inches high, 57.625 inches wide, and 26.241 inches deep. The top of the cabinet must be 57.925 inches wide and 28.7 inches deep. The top of the cabinet must have a front to rear slope that will direct rain away from the front cabinet door. Door openings must be double-flanged. The interior of the cabinet will be divided into two compartments. The interior of the main cabinet must be equipped with four (4) "C" mounting channels on both side walls and two (2) "C" mounting channels on the rear wall. The UPS portion of the cabinet must be equipped with two (2) "C" mounting channels on each of the two side walls. All shelves, panels and individual equipment items must be mounted to these channels using 1.0" channel nuts with 1/4-20 bolts. All items mounted on panels must be securely fastened by bolting into drilled and tapped holes. No pop rivet or similar fastening methods will be accepted. The cabinet manufacturer will be Erpel, Hennessy, Southern Manufacturing Company, or approved equals.

4.2 Doors. The cabinet must have a main door hinged with one-quarter inch (1/4") minimum, continuous, removable stainless steel pins. The hinges themselves will be aluminum secured to the cabinet with stainless steel bolts. The battery compartment door on the side of the cabinet must be similarly hinged. The main cabinet door will be hinged on the right side. The battery compartment door will be hinged on the left side. The doors must be closely fitted to a neoprene gasket making the doors dust, water and weather resistant. The doors must be interchangeable with any other doors from any other controller in this order.

Opening of the main door must provide complete access to the cabinet interior. The door must be embossed, subject to approval, with the legend "CITY OF CHICAGO-TRAFFIC CONTROL" in letters at least one (1) inch high. The main door and the battery compartment door must have stops at 90, 150 and 180 degrees, from the closed position. The door latches must have three (3) point locking with rollers at the ends of the latch rods. The latch handle must be capable of being padlocked. The key lock for the latch mechanism must be a Corbin cylinder lock with keys to match existing City of Chicago controller cabinets. Two (2) keys must be furnished with each cabinet. Both the main door and the battery compartment door will have stainless steel handles with an 8" shank. The handles must be able to be padlocked. The padlocking arrangement must clear the lock and key.

Police Panel Door. The police panel door on the main door must be furnished with a lock for a modified Chicago police key per sample to be furnished to the supplier. This key must have a shaft of at least one and three quarter inches (1-3/4") in length. Two keys must be furnished with each cabinet. The door will have a stainless steel piano hinge and be sealed with a neoprene gasket.

Generator Door. This door will be on the rear of the cabinet. This door will have a stainless steel piano hinge and be sealed with a neoprene gasket. Two keys will be furnished for this door.

4.3 Cabinet Ventilation. The main cabinet compartment must be provided with a amounting assembly to hold the forced air fan system. A fan, having a minimum air movement capacity of 100 CFM, must be mounted in the air baffle in the top of the cabinet with an air outlet built into the roof overhang. The main door must be louvered and equipped with a removable, standard, commercially available aluminum dust filter. The battery compartment must have a similar fan system. The battery compartment door must also have a louvered section with a removable dust filter. The ventilation openings must be equipped with removable covers for summer operation. No external fan housings or air outlets will be allowed. Any other method must be approved.

4.4 Shelves. The cabinet must contain a vertically adjustable shelf large enough to accept the solid state controller and all other shelf mounted devices. The battery

compartment must have a minimum of three shelves.

4.5 Bolt Pattern The bolt pattern must be a four (4) point rectangular pattern matching the corresponding foundation. The dimensions will be 40.75" center-to-center and 18.5" center-to-center.

4.6 Finish. The exterior surfaces of the cabinet must be smooth. All drilled, tapped, or punched holes on the outer surface must be filled with liquid metal and ground smooth, and slotted screw heads must be ground smooth flush with surface. Bolts extending through cabinet wall must be round head, carriage, square shoulder type and fastened on the inside of the cabinet with an Esna nut and necessary gaskets to insure the weatherproofing integrity of the cabinet. The finished cabinet must be thoroughly degreased in a wash process and dried in a heated chamber. A thermosetting, ultra violet resistant, polyester powder coat must be electrostatically applied to all cleaned and treated surfaces and cured to a hard, mar resistant finish in a heated chamber at a temperature recommended by the powder coat paint manufacturer. Exterior color must conform to Federal Standard 595, and either be City of Chicago green color No. 14110 or gloss black color. Exterior color must be as defined in the PROPOSAL or Contract Plans, and color samples must be submitted for approval prior to acceptance of cabinet. Cabinet interior must be glossy white and may be either baked enamel or thermosetting, polyester powder coat. For either process, the interior must be prepared as described above. If the baked enamel finish is used, it must be preceded by one (1) coat of primer.

5. POWER SUPPLY

5.1 A sixty (60) ampere main breaker must be inserted in series with the line.

5.2 An unfused terminal bus must be provided for ground side of the power supply and signal conductor commons.

5.3 Individual circuit breakers must be supplied for: (a) AC+ lights, 50 amperes; (b) AC+ control, 10 amperes; (c) duplex outlet supply, 15 amperes.

5.4 The incoming line must contain lightning protection devices consisting of, but not limited to, a metal oxide varistor and gas type arrestor. The gas type arrestor must be on the line side of the radio interference filter.

5.5 Contactor**.** A sixty (60) ampere Magnacraft, or approved equivalent, normally open, "A" type mercury contactor must be supplied for opening and closing the AC supply to the signal bus. This contactor must be mounted in such a manner on the power supply panel that accidental contact does not produce a safety hazard.

5.6 R.I.S. Filter. A radio interference suppression filter rated at sixty (60) amperes minimum must be installed in line with the main power supply, after the sixty (60) ampere circuit breaker.

5.7 Ground. The grounded side of the power supply must be continuous throughout the controller and must be grounded to the controller cabinet in an approved manner meeting OSHA requirements.

5.8 Polarity. The phase conductors of the signal circuits must have the same polarity as the phase side of the power supply, and the common conductor(s) must be of the same polarity as the grounded side of the power supply.

6. UNINTERRUPTIBLE POWER SUPPLY

6.1 General. The uninterruptible power supply will consist of batteries which will recharge through the 120 volt electric service line. In the event of a power disruption, the unit will automatically activate. The transfer from utility power to battery power will not interfere with the normal operations of the traffic controller, conflict monitor, or any other part of the traffic system. A generator port will be provided to accept input from an external generator that can operate the traffic signals. The UPS must be the product of an established manufacturer, and suitable for the service required. The UPS must be manufactured by U.S. Traffic Corporation, On-Line Power, Inc., or an approved equal.

6.2 General Operation

(1) The line power provided by ComEd is nominally 120 volt, single phase, 60 Hertz. The UPS system will take the line power, regulate it, and provide continuous 120 volt, single phase, 60 hertz power to the traffic system. The UPS will regulate the input line voltage within the limits specified herein. The input line voltage will also be transformed and rectified to charge the batteries. Under battery operation, the output from the batteries will go through an invertor to provide the proper A.C. current to provide continuous 120 volt, single cycle, 60 Hertz power to the traffic system. In the event of a power loss, the system will automatically switch to battery operation, without adversely affecting the traffic system. When power is restored, the system must automatically switch back without adversely affecting the traffic system. In the event the UPS system fails, an automatic switch must bypass the UPS and connect unconditioned power from ComEd directly to the traffic system. A manual bypass switch must also be provided. The system must be capable of running off a generator. The UPS will allow the generator to be put in or out of the system without

adversely affecting the traffic system.

(2) The system will be capable of providing power for normal full timing mode, flash mode, or a combination of both. The operation will be field programmable to activate at various times, to change operation due to changing battery capacities, and to track alarm conditions, using the touch pad or remotely using the RS-232 interface. Programmability must be in ASCII formats and must not require any external or proprietary software. The DB-9 connector for the RS-232 interface must be located on the front panel of the UPS. The UPS must provide a minimum of 4 hours of full normal timing for a full LED controlled intersection.

(3) In the event ComEd line voltage falls outside the high and low limits (95VAC and 130VAC should be the default values) the UPS must transfer the load to battery power. The high and low limits must be programmable.

(4) The UPS must return to line mode when the ComEd power is restored within the proper limits for a specified period of time. The limits must be programmable. The default values should be 105VAC and 125VAC. This time must be programmable and should range from 3 to 30 seconds.

(5) The transfer time allowed, from disruption of normal utility line voltage to batteries or from batteries back to line voltage, must be such that the traffic signal system is not disrupted. The maximum transfer time allowed will be 60 milliseconds.

6.3 Specifications

(1) The UPS capacity will be a minimum of 2000VoltAmps/ 1500 watts.

(2) The inverter must have a minimum efficiency of 80%.

(3) The UPS will have an operating range of between -37°C. to +74°C.

(4) The manual bypass switch must be rated at 240 volts, 40 amps.

(5) The UPS must have a temperature compensated battery charging system. The charging system must compensate over a range of 2.5mV to 4 mV per degree centigrade per cell. Batteries must not be charged when temperatures exceed 50°C. The temperature sensor must be located in the cabinet near the batteries.

(6) The charger must be rated at 10 amps at 48 VDC.

(7) When under battery operation the UPS output voltage must be between 110 VAC and 125VAC, with a sine wave with THD less than 3% at 60 Hertz(±3 Hz).

(8) The UPS must be equipped to prevent a malfunction feedback to the utility service or to the cabinet per UL 1778, Section 48 "Back-Feed Protection Test". The upstream back-feed voltage from the UPS must be less than 1 volt AC.

(9) The UPS must have a lightning surge protection in compliance with IEEE/ ANSI C.62.41 for 2000 volts AC.

(10) The UPS must not weigh more than 50 pounds.

(11) The UPS must have a minimum efficiency of 95%.

(12) The generator bypass switch must be supplied with a 30 amp, weather-proof locking receptacle and cover plate.

6.4 Computer Control and Display

(1) The UPS must include an LCD display with programmable keypad, a red LED and a green LED, and an RS-232 interface.

(2) The UPS processor must be capable of indicating, through the LCD display or the RS-232 interface, the current battery charge status, various input/output voltages, power output, battery temperature, date, time, settings of programmable relays, events, and various other functions.

(3) The UPS must provide a temperature control for the cabinet fan.

(4) The UPS must be provided with a resettable inverter event counter and a cumulative inverter timer.

(5) The UPS must be equipped with an event log for a minimum of 100 events. Each event must have a date and time.

(6) The UPS must be capable of performing a self-test.

(7) Password protection must be provided.

(8) The following LED conditions must be used to indicate current status:

RED FLASHING - Alarm
RED STEADY - Fault
GREEN FLASHING - Battery Mode
GREEN STEADY - Line Mode

(9) The manual UPS bypass switch will allow the UPS to be maintained or replaced.

6.5 Battery System

(1) Individual batteries must be 12 volt, and must be commercially available and easily replaced.

(2) Four 79ah batteries must be supplied.

(3) The batteries will be connected in series. The wiring harness must be color coded with quick disconnects.

(4) Batteries must be certified to operate over a temperature range of -25° C. to +74° C.

(5) The batteries must be extreme temperature, deep cycle, sealed prismatic lead-calcium based AGM/VRLA (absorbed glass mat/valve regulated lead acid) .

(6) Maximum recharge time from protective low cut-off to 80% of full capacity must not exceed 20 hours.

(7) Thermostat controlled heater strips or pads must be supplied to keep battery operation efficient.

6.6 Relay Contacts

(1) The UPS must provide 6 sets of panel-mounted, potential free, fully programmable relay contacts rated at 1 amp, 120 volt. The relays must be numbered from C1 to C6.

(2) Each relay must be programmable to activate under any number of the following conditions:

ON BATTERY, relay activates when UPS switches to battery power.
LOW BATTERY, relay activates when batteries have reached a certain level of remaining capacity. This is adjustable from 0 to100%.
TIMER, relay activates after battery power is on for a certain amount of time. This is adjustable from 0 to 8 hours.

ALARM, relay activates after a specific alarm is detected. Alarm conditions include line frequency, low output voltage, no temperature reading, overload, batteries not connected, high temperature, and low temperature.

FAULT, relay activates after a specific fault is detected. Fault conditions include short circuitry, low battery voltage, high battery voltage, high internal temperature, and excessive overload.

OFF, relay is not active.

7. LOAD SWITCH BAY

7.1 General. A panel must be provided for mounting the load switch jacks, flash transfer relay jacks, flasher jack, auxiliary relays, time clock jacks, switches, flash change combination terminals, and terminals for field signal connections under non-interconnected operation. See Electrical Standard Drawings 964 and 965.

7.2 Wiring. Panel wiring must be neatly laced and properly terminated individual conductors. They must be insulated and properly sized for their application.

7.3 Load Circuits. Each load circuit must be capable of carrying fifteen (15) amperes continuously at a temperature of 165° F. (74° C.).

7.4 Bus Feeds. Bus feeds must be capable of carrying fifty (50) amperes continuously at a temperature of 165° F. (74° C.).

7.5 Equipment. In addition to the items listed in 2(a), the wiring panel must include, but not be limited to, the following:

(1) Ten (10) ampere fuses with barrier type fuse holders must be installed between the load switch signal output circuits and field terminals for signal light conductors. Each terminal must be the barrier type with sufficiently long screws to accept four (4) #12 AWG solid conductors. The terminals must be located at least two inches (2") above the bottom of the cabinet.

(2) Switching Device. The signal load switching device must be a three (3) circuit, solid state, jack mounted load switch which meets the N.E.M.A. Publication TS-1, Part 5 requirements. Each load switch must be rated for a minimum fifteen (15) ampere continuous resistive load and must mate with an S-2412-SB panel socket. A minimum of twelve (12) and a maximum of sixteen (16) load switches to be provided with each cabinet, as defined in the PROPOSAL or Contract Plans.

(3) User Programmable Interface. Two (2) sets of terminal blocks must be

provided between the machine logic output and the input side of the load switches. By terminating all machine logic output on one set of terminals and all load switch input to the other set, an interface is thus created by which the machine logic can be readily connected to any of the load switches by means of a jumper wire. The two (2) sets of terminal blocks must be conveniently located in close proximity to each other and must be arranged such that, initially, each function will be factory wired directly from one set of terminals to the other without the need to criss-cross wires between blocks.

(4) Number of Signal Circuits:

a. Sixteen (16) load bay panel. Each panel must be equipped with sixteen (16) load switch jacks for a minimum of forty-eight (48) signal circuits.

b. All unused signal circuits must be neatly tied or terminated. If tied, the harness wire must be labeled. If terminated, each termination must be identified.

7.6 Identification. All field terminals must be suitably identified, subject to approval.

8. FLASHING FEATURE

8.1 General. The flasher must be a solid state device, with no contact points or moving parts, producing between 50 and 60 flashes per minute with a 40 to 50 percent duty cycle. The flasher mechanism must be mounted on a type P-406-SB plug which will mate with an S-406-SB socket on the controller panel. The flasher must utilize zero-point switching, with turn-on at the zero voltage point (± 5 degrees) of the power line sinusoid.

8.2 Flasher Panel. A panel must be provided with one (1) terminal wired to the flasher and marked "FL". The panel must be equipped with terminals to provide or omit flashing of all red and yellow outputs.

8.3 Flasher Circuits. Flashers must provide two (2) output circuits to permit alternate flashing of signal phases and must be capable of carrying a minimum of twenty (20) amperes per circuit at 120 volts. The flasher must operate continuously so that flashing power will be available at the field terminal marked "FL". The flasher wiring must divide the loads imposed on the two (2) circuit flasher alternately on each phase.

8.4 Manual Flash. A manual flash switch must provide flashing indication for all circuits. The flash change combination terminals must allow the selection of flashing either yellow or red on the main and/or cross streets, or complete

omission of the flashing feature if required.

9. POLICE PANEL

9.1 Auto-Off Flash Switch. Each controller must be provided with an auto-off-flash switch. In the "AUTO" position the signals will be on and the controller timing unit will run normally. In the "OFF" position the signals will be OFF and the controller timing unit will continue to run. In the "FLASH" position the signals will flash and the controller timing unit will continue to run. The auto-off flash switch must be located on the side of the police switch panel that faces outward when the police door is open.

9.2 Auto-Hand Switch. Each controller will have an auto-hand switch on the back side of the police switch panel. This switch must be so arranged that the switch can be physically rotated 180 degrees to provide usage after opening the police panel door. It must be so mounted that the act of rotation does not affect the police switch panel. Switch terminals must not be exposed on either position. The auto-hand switch must provide a means of manually timing the signals by use of a separate, momentary contact, hand switch. Operation of the timer by manual control must provide the same color sequence as an automatic operation with no momentary undesirable indications appearing. Manual control must be possible with the door of the cabinet closed. The hand switch required for manual control must only be supplied when specified in the PROPOSAL. It must be of an approved weatherproof construction with a six (6) foot, retractable, flexible, extension cord to allow connection to the appropriate terminals on the panel of the controller. It must be possible to manually step through a vehicle clearance interval.

9.3 Terminal Block. A two point terminal block must be mounted on the back side of the police switch panel and the hand control circuit terminated on this block. This will be for installation of a hand control cord by others, as required.

9.4 Space Requirement. Adequate room must be provided in the police panel section to store the manual switch and retractable cord.

10. RELAYS

10.1 Transfer Relays. Eight (8) double pole, double throw, flash transfer relays must be furnished with each controller. These relays must be jack mounted into an S-408-SB, or equivalent, socket mounted on the controller panel.

10.2 Contact Arm. Each contact arm must have over travel on the front and back contacts and be independent of any other contact arms. No adjustment of contact pressure or wipe must be necessary. Load capability must be a minimum of fifteen (15) amperes per contact continuously and thirty (30) amperes for one (1) minute. Contacts must be of coin or fine silver or an approved alternate.

10.3 Dust Cover. A suitable dust cover must be furnished for each relay.

10.4 Relay Mounting and Endurance. All relays supplied must meet their approved specified requirements and must have contacts which cannot be opened by unusual vibrations, shock, or momentary voltage excursions of up to 30%. All relays other than the flash and bus relay must be mounted on a molded base with eleven (11) or eight (8) pins for jack mounting to their respective panel or sub-base, and must be electrically interchangeable with those presently used by the City of Chicago ("MIDTEX", Model 158-92T200 or equal).

11. COMMUNICATIONS INTERFACE PANEL

11.1 Where a communications interface has been specified in the PROPOSAL or contract plans to allow a controller to function as a Master or Secondary controller, then one of the specified options must be provided:

(1) Fiber Optic Communications Interfaces must meet the following requirements:

a. General. The fiber optic communications components must consist of, but not be limited to, an internal fiber optic modem within the controller or an external fiber optic modem, a fiber optic patch panel to interface the modem to field fiber optic cables, and fiber optic jumpers between the modem and patch panel.

b. The modem must either be a multi-directional "star" type or a bi-directional type, as specified in the PROPOSAL or contract plans. All modems must be Electronic Industries Association (EIA) compatible for RS-232 data communications via fiber optic link. Modems must be multi-mode, operate at 850nm wavelength, and provide full-duplex, frequency modulated, asynchronous transmission at data rates of up to 38.4 kbps.

c. The fiber optic patch panel must consist of a 14" long by 5-3/4" wide by 3-1/4" high rack constructed in accordance with City of Chicago Electrical Standard Drawing #909. The rack must be designed to mount on the controller cabinet rails. "ST" type terminals, suitably labeled, must be provided for the connection of field fibers and Modem.

d. The fiber optic jumpers (i.e., optical patch cords) must consist of a single multi-mode fiber in 900 micron orange jacket, with "ST" type connectors factory installed on each end. The jumpers must be 3' long in Secondary (i.e., local) controller cabinets and 6' long in Master controller cabinets. The jumpers must be connected to the

patch panel and supported in such a manner that the minimum bending radius is ten (10) times the diameter of the cable, and the cables exert no strain on the connectors. Each jumper must have a minimum tensile strength of 50 lbs.

(2) Copper Wire Interconnect Panels (Seven Wire, VAC) must meet the following requirements:

a. General. The interconnect panel must serve to isolate interconnect VAC from the controller. The panel must consist of, but not be limited to, seven (7) relays. Each relay interconnect circuit must include an M.O.V. properly rated for protection against lightning and switching surges injurious to the controller and a barrier type 3AG fuse receptacle and fuse not to exceed five (5) amperes. Each panel must provide a seven (7) wire interface with the T.B.C. functions described below and must provide barrier type terminals suitably labeled for these functions.

b. The secondary interconnect panel must be wired in such a manner that an VAC input activates a relay sending an input from that relay to the controller. It must have a minimum of seven (7) relays for the following functions; Dial 2, Dial 3, Dial 4, Offset 1, Offset 2, Offset 3, M.U.T.C.D. flash.

c. The master interconnect panel must provide a means to establish outgoing VAC for a seven (7) wire interconnect system using eight (8) relays. The relays must have 24 VDC coils and be designated as, Dial 2, Dial 3, Dial 4, Sync, Offset 1, Offset 2, Offset 3, M.U.T.C.D. flash. The sync relay must be wired in such a manner that it provides the offset pulse to the contacts of the three (3) Offset relays.

d. Each relay must be a double pole type, with one pole designated as field interconnect output, and the other designated as controller input. Relay coils must be rated for continuous duty. Relay contacts must be rated for a continuous fifteen (15) AMP resistive load.

e. A terminal strip must be mounted on the top of the master interconnect panel for controller interface.

f. The master panel must interface with the T.B.C. terminals as described above.

g. Each output must be fused as outlined above.

12. RAILROAD INTERCONNECT REQUIREMENTS

12.1 General. The railroad preemption will meet the requirements of the ICC (Illinois Commerce Commission) and the requirements of IDOT (Illinois Department of Transportation).

12.2 IDOT. The railroad preemption will meet all the requirements of the Illinois Department of Transportation's Standard Specifications for Road and Bridge Construction, adopted January 1, 2007. It must meet all the requirements of Article 1073.01 (c) (2) and Article 1074.03 (a) (5) e.

12.3 ICC. The railroad preemption will meet all the requirements of the Illinois Commerce Commission, as stated herein.

(1) The railroad preempt relays and the City traffic cabinet in general must be able to be wired as indicated in IDOT's Standard 857006-01 "SUPERVISED RAILROAD INTERCONNECT CIRCUIT". A failure in the interconnection circuit will result in activation of a supervisory failure alarm.

(2) Remote Flash. The Remote Flash input to the controller must be inverted from normal NEMA logic. Instead of grounding the input to Logic Ground (0 volts DC) to activate, the Remote Flash will be normally grounded and will be activated when the input is in the Logic 1 (+24 volts DC) state. This will preclude the installation of a controller without the proper railroad software and a normal controller with standard (non-railroad) software will not be able to run the traffic signals.

(3) Critical Components Series Loop. All critical components to railroad preemption such as relays and harnesses must utilize the 24 VOLT DC monitor voltage to form a series loop. Removal of any component will result in the traffic signals entering a flashing red condition. The 24 VOLT latch in the Management Malfunction Unit will be programmed, requiring manual reset if a failure in the series loop occurs.

(4) Controller Preempt Input Verification. Like the supervisory interconnection circuit monitors the integrity of the interconnect cable, this feature monitors the integrity of the controller railroad preemption input and associated wiring within the traffic controller cabinet. This will utilize a secondary railroad preemption input that is normally active (on) when no demand for railroad preemption is present. When a demand for railroad preemption is received, the normal railroad preemptor input is applied and the secondary input is dropped. If both inputs are either simultaneously on or simultaneously off for a time period of more than one (1) second, the controller will recognize this as an input failure. When a failure

occurs, the traffic controller will be configured to provide a track clearance interval followed by a flashing red condition. This occurrence will set a preempt input alarm and also will require a manual reset of the controller.

(5) Track Clearance Green Re-service. Any demand for railroad preemption received at any point in the normal sequence, the emergency vehicle preemption sequence, a bus preemption sequence, or any other form of low priority preemption, or a previously called for railroad preemption sequence will result in the traffic controller providing a track clearance green indication within a "maximum time to track clearance green " (usually 8 seconds depending upon site specific criteria) and will provide a full track clearance green time interval after the preemption demand was received. The controller software must have the capability to restart the railroad preemption sequence providing a full track clearance green interval from any point within the railroad preemption sequence from the start of track clear green through the entire dwell/hold interval(s) including any exit yellow and red clearance intervals, if the demand for preemption drops and is reapplied. The number of times the controller is able to react to successive demands for railroad preemption must not be limited. This will be a software based routine that does not require any user programming and must be designed into the software.

(6) Preemption Priority. Preemptor number 1 is typically assigned to a supervisory failure in the interconnection circuit and preemptor 2 is typically assigned to a normal railroad preemption demand. Preemptor 1 must have priority over preemptor 2. Preemptor 2 must have priority over all other forms of preemption.

(7) Delay Time. In order to compensate for noisy or intermittent calls, the controller must have a programmable delay timing parameter for railroad preemptors, programmed at 1 second. Any demands for railroad preemption lasting less than this time will be ignored. This will apply to any subsequent demands for railroad preemption that may occur while the controller is still within the railroad preemption sequence from a prior demand.

(8) Non-Locking Preemption. The controller must have the capability to configure the railroad preemptors as non-locking calls. If a demand for preemption is placed for a duration of less than 1second (as programmed in the delay timer), the call will not lock and the controller will not initiate the preemption sequence. Furthermore, if an initial demand for preemption is dropped prematurely while the preemption sequence is still timing, the non-locking feature will allow the controller to re-service another demand for preemption.

(9) Minimum Green before Preemption. The controller must have a separate minimum green timing parameter, programmed at 1 second, that replaces normal controller phase minimum green times when entering railroad preemption. When a demand for preemption is applied, any active phase(s) must terminate immediately or after they have been active for 1 second if the demand occurs at the start of the phase(s). If any indications that are part of the track clearance green are active when the demand for railroad preemption is placed, those indications will not terminate until after the track clearance green interval is completed.

(10) Railroad Hold/Dwell Interval. The controller must have the capability to display a programmable phase(s) and rest in that phase(s) until the demand for railroad preemption is released. The controller must also have the option to cycle between a set of programmable phases that don't conflict with the railroad crossing, or rest in an all-red steady state until the demand is released. The necessity for cycling during the hold interval or the use of an all-red steady state is determined by an assessment of the specific site. The controller must have a timing parameter that will provide a minimum hold/dwell time, even if the demand for preemption is dropped prematurely. The controller must be able to re-service any subsequent demands for preemption during this minimum hold/dwell time.

(11) Railroad Hold/Dwell Extension. The controller must have a timing parameter that will extend the hold/dwell interval for a programmed time after the demand for railroad preemption has been released. The controller must be able to re-service any subsequent demands for preemption during this extension time.

(12) Pre-signal Timing. When pre-signals are present in advance of a railroad crossing, during normal operation the pre-signal green indications terminate a programmable time (timed overlap) prior to the indications at the intersection. The duration of the timed overlap should not be reduced when leaving normal operation to service other forms of preemption, such as emergency vehicle or bus preemption. If a demand for railroad preemption occurs during the timed overlap portion of the normal sequence, the overlap timer must terminate and the track clear green interval must begin immediately, after the pre-signal yellow and red vehicle clearance intervals are completed.

(13) Remote Monitoring and Alarms. Capabilities to remotely monitor the traffic controller must be provided, including the capability to monitor the operation of the controller, upload logs/events, and to verify the integrity of the database. In addition, the controller must

have the ability to automatically report alarms, such as preempt 1 activation, preemptor input failure, automatic flash, CRC failure, 24 volt failure, and other defined alarms. The controller must have the ability to prevent the remote download of changes to the critical data protected by the railroad preemption security feature.

(14) Blank-out Signs. If these signs are used for railroad preemption, they should activate immediately with the activation of the railroad interconnect circuit. They should deactivate immediately with the deactivation of the interconnect circuit, not after the controller exits the railroad preemption sequence. Whenever the traffic signals are in flashing red operation, cabinet circuitry must be such that the signs will remain operational if the interconnect circuit activates due to railroad warning device activation.

12.4 CRC. A CRC module with all connections, a USB memory device, software, and any other firmware necessary to make the CRC fully functional will be provided if so designated.

(1) Hardware. A 16 bit CRC (cyclical redundancy check) module must be provided. The module will connect to the ATC controller using unused I/O pins. Reassignment of unused inputs on the NEMA 'A', 'B', and 'C' connector I/O pins or connection to a proprietary 'D' module's input pins will be acceptable. The final CRC value for the specific intersection requirements will be set on the module for that intersection. Removing the CRC module during normal operation of the intersection, or mismatching the values in the database and the CRC, will result in a fault condition and put the intersection in flash mode.

(2) Software. The controller software/firmware will provide the logic and control facilities to fully implement CRC error detection. All the data elements (objects) required for the implementation will be contained in a proprietary data block. The software will provide a mechanism to "display" the final CRC value to be set on the CRC module.

A USB memory device will be utilized to 'lock' or 'unlock' the database. When the USB device is inserted into the controller, the controller will display a menu that will include a utility to 'unlock' the database. The USB device will contain a file structure that will allow access to the protected areas of the database. Once 'unlocked', the database can be edited through normal user interfaces. While the database is 'unlocked', the controller will drop the voltage/fault monitor signal to the conflict monitor to keep the intersection in flash. The CRC comparison check will be disabled during this period.

After all the changes to the database are completed, the user will use a utility on the USB to 'lock' the database. After the database is 'locked', another utility will allow the calculated CRC to be displayed. This can be used to configure the CRC module. After the CRC is connected and the USB is removed from the controller, the voltage/fault monitor signal to the conflict monitor will be enabled. A restart will be required to restart the controller.

Once the CRC module has been set (programmed), and the database has been locked, the controller can resume normal operation. The controller firmware will validate the stored CRC against the CRC module's value at least once per second.

13. WIRING

13.1 General. All electrical conductors must be stranded copper, with a minimum of nineteen (19) strands per conductor, and a concentrically applied 90° C. insulation with a 600 VAC rating. Wiring from the fuse block to the first distribution point, and to the controller bus, must be No. 10 AWG. Signal circuit wire must be No. 14 AWG. The wires must be provided with lugs or other approved terminal fittings for attachment to binding posts. All wiring between various parts of the controller must be neatly cabled. All wiring and terminal blocks must be tested for possible short circuits and resistance to ground by a high voltage dielectric test at 1,200 VAC. A wiring harness of adequate length must be provided to the timing device to allow the timer to be placed on top of the cabinet when required.

13.2 All VAC connections to load switches, flasher, and flash transfer relays must be soldered. All VAC connections on back of terminals must be soldered.

13.3 All VDC connections on back of terminals, and load switches must be soldered or connected with pre-approved terminations. All VDC connections to load switches are to be soldered or connected in a manner pre-approved by the City of Chicago's Division of Electrical Operations.

14. TESTING REQUIREMENTS

14.1 General. In addition to the testing required in the ATC standard, the following test requirements must be utilized:

14.2 N.E.M.A. Environmental Test. One controller, the submitted sample unless approved otherwise, must be tested, at the manufacturer's expense, in accordance with Part 2 of NEMA Standards Publication TS1-1983. All of the tests listed must be performed with all data properly recorded and certified. If the manufacturer changes the design, fabrication or components of a previously

tested and approved controller, then a sample of the controller containing the new design, fabrication or components must be retested at the manufacturer's expense. Any N.E.M.A. environmental test references to minimum recall must include but not be limited to: All forty-eight (48) output circuits must be programmed in a sequence to simulate the normal functioning of the entire controller cabinet assembly; The conflict monitor must have a test board with the allowable channel jumpers installed to simulate normal operation; All thirty-two (32) intervals must be programmed with a minimum of two (2) seconds per interval.

14.3 Functional "Burn In" Testing. The "burn in" requirement must include a test that uses all forty-eight (48) output circuits in "solid" burn as well as 1 pps and 5 pps for each circuit. All thirty-two (32) intervals must be programmed with a minimum of two (2) seconds per interval. The documentation for a test program to simulate the normal functioning of the controller phasing must be supplied. A copy of the test program must be approved by the City of Chicago, Division of Electrical Operations prior to testing.

14.4 Testing Requirements. In addition to the NEMA environmental test and the "burn-in" requirements stated above, satisfactory performance of the traffic signal cabinet and its equipment must be demonstrated prior to shipment from the factory. The manufacturer must submit five (5) copies of his proposed "Test Procedure Document" for approval with the sample requested above. The test procedure must consist of two (2) sections; physical inspection and functional testing. If the test procedure is judged by the Commissioner or his duly authorized representative to be incomplete, inadequate or otherwise deficient, the contractor must revise and resubmit his "test procedure document" until it is approved. No contract can be awarded until the "test procedure document" has been approved.

14.5 UPS. Testing of the equipment must verify that the operation meets the requirements of this specification. All equipment must be shown to operate correctly, including the rectifier, charger, inverter, batteries, and control unit. The UPS must be connected to a dummy load at the factory and tested for performance under various conditions of line voltage and frequency, varying loads, temperature range, and humidity range. The automatic switching must be successfully demonstrated; losing line power and restoration of line power must not adversely affect the operation of the traffic signals. Use of the manual bypass switch must be successfully demonstrated. A generator must be connected to the unit and successfully operate the system without interruption. The batteries must be shown to be able to operate the traffic signals for the specified time. The batteries must be shown to be able to be recharged in the specified time between failures. The control unit, including the LCD display and the RS-232 interface, must be shown to function according to this specification. All reports and event monitoring must be successfully demonstrated. Programming functions must also be shown to work properly.

14.6 Performance Testing Documentation. Upon completion of the performance testing, two (2) certified copies of the final results of the approved "Test Procedure Document" must be included with all traffic signal controller production shipments.

14.7 Testing, Certification and Observation. Each traffic signal controller ordered must be tested in accordance with the approved "Test Procedure" document. The City's representative(s) must observe the manufacturer's testing in progress. The City must be notified at least thirty (30) calendar days prior to testing, and no testing will be initiated without the presence of its representative(s). The representative(s) may observe all, or a portion, of the tests, as he (they) may deem necessary. Certification documents that the traffic signal controller has been tested in accordance with the Test Procedures documents, and the results of these tests, must be signed by the individual(s) performing the tests and their immediate engineering supervisor. Two (2) copies of each certification document must be delivered with each production traffic signal controller. The contractor must include in his bid the cost of travel, food and lodging for two (2) engineers. Travel for 150 miles or greater must utilize a major airline. Lodging accommodations must be equal to those provided at a Holiday Inn.

14.8 Physical Inspection. The "physical inspection" portion of the test procedure document must require the manufacturer to perform a physical inspection of workmanship and specification compliance for each traffic signal controller assembly. The inspection must be done using a detailed check list defining items to be inspected and criteria for acceptance. The inspection must include, but not be limited to, the following items:

(1) Hardware installation.
(2) Assembly mounting.
(3) Dimensions.
(4) Presence of specified devices and materials.
(5) Presence of required documents.
(6) Labeling and required serial numbers.
(7) Wiring including routing, covering, gauge, length, and soldering of terminations.
(8) Arrangement of equipment for safety and ease of calibration reprogramming troubleshooting and maintenance.
(9) Condition of cabinet body and finish.
(10) Condition and installation of doors, panels, gaskets and ventilation.
(11) High voltage test of insulation resistance to ground, with wires installed in cabinet and equipment disconnected.

14.9 Functional Testing. The "functional testing" portion of the Test Procedure must require the manufacturer to perform a complete room-temperature functional test of each complete traffic signal controller assembly for a minimum of

seventy-two (72) hours. This test must be designed to concurrently check integrated hardware systems e.g., from simulated input to load switch output including conflict monitor and time base coordinator. All interface/controller interconnections must be tested. All load switch and interconnect relay positions must be tested, regardless of the number of load switches and interconnect relays being purchased. The functions tested must include, but not be limited to, the following:

(1) Flash logic and operation (color, phases).
(2) Conflict monitor logic and operation.
(3) Police panel switch operation.
(4) Auxiliary panel switches (including fans).
(5) Interface panel.
(6) Time switch operation.
(7) Load switches (with a continuous ten (10) ampere load on each signal circuit).
(8) Outputs.
(9) Power interruptions of less than 500 ms.
(10) Power interruptions of more than 1.0 sec.
Generator Hook-up.

15. SHIPMENT AND DELIVERY

15.1 Packaging. The cabinets must be shipped on individual pallets. Each cabinet must be individually wrapped and protected so that it can be handled without damage to the cabinet or its finish. The UPS and cabinet must be wrapped to give protection from the elements, as well as from shipping. If subassemblies or parts are ordered they must be suitably packaged to prevent damage during shipping and handling. All packages should be clearly labeled indicating the contents.

15.2 Delivery. The assembled cabinets, or subassemblies and parts, must be delivered to the Division of Electrical Operations at 2451 S. Ashland Avenue, unless otherwise directed. Assembled cabinets, or subassemblies and parts, must be available for testing and shipping within six weeks of the placement of an order.

16. INSPECTION

16.1 An inspector representing the City must have free entry at all times, while the work on the contract is being performed, to all parts of the manufacturer's plant which concern the manufacture of the equipment. The manufacturer must afford the inspector, without charge, all reasonable facilities to satisfy the inspector that the equipment is being furnished in accord with these specifications.

CHICAGO ATC MATRIX - TABLE A

Since the ATC standard specifies a "family" of controllers, the following options have been selected from the ATC standard to meet the City's needs.

Functional Requirement	ATC Clause #	Status	Details
Shelf Mounted	2.2.1 4.3.2.1	Required	(Shelf mount only)
Use of ATC Engine Board	2.2.2 4.3.2.2 5.1.1 5.1.2 5.3.2 5.3.4 5.3.5 5.3.5.1 5.4.2 5.4.3 5.4.4 5.4.5	Required	
Use of ATC Engine Board	5.2.1	Required	□ Allowed component height below Engine Board PCB provided that the overall envelope remains unchanged, the clearance between the Host Board and Engine Board remains as specified, and the Engine Board still fits into a compliant Host Board
Use of ATC Engine Board	5.2.2 5.4.5	Required	In order to show the Ethernet communications to the Engine Board, the following "Reserved" pins can assume the following legacy functions: □ P1-34: ENET2 Speed □ P1-35: ENET2 Link/Activity □ P1-36: ENET1 Speed □ P1-37: ENET1 Link/Activity
Use of ATC Engine Board	5.3.1	Required	Minimum CPU capability of 500 MIPS
Use of ATC Engine Board	5.3.3	Required	Additionally, must provide a minimum of 16 MB of Flash total to accommodate future applications.

	5.4.1	Required	□ Engine Board shall not draw more than 4W of power from VPRIMARY (due to battery backup in Chicago) □ Engine **may** supplement VSTANDBY_5 with on-board storage for its standby power.
Use of ATC Engine Board Use of ATC Engine Board	5.4.3	Required Required	□ All optional baud rates shall be supported □ Only one modem slot to be provided (due to space restrictions) and not labeled
Modem Slot Modem Slot	2.2.3 4.3.2.3 6.1 6.1.1 6.1.2 6.2.2 6.2.1 6.3.1.3 6.3.1 6.3.1.1 6.3.1.2 6.3.1.5	Required	□ Reduced modem slot pin-out □ +12VDC ISO and DCGND2 are not required to be supported □
Parallel I/O	2.2.4 2.2.5 4.3.1 4.3.3 2.2.5 4.3.1 4.3.3	Required Required	□ No support required for TS2 Type 1 or ITS cabinets □ Must provide parallel I/O for TS2 Type 2 cabinets and legacy parallel I/O interfaces via interchangeable modules
Linux O/S and ATC BSP			
Linux O/S and ATC BSP		Required	
Linux Kernel	Annex A	Required	
Parallel I/O	3.4 3.5.1.3	Required Required	Not required to support ITS Cabinet standard (NEMA cabinets are used) Must also support synchronization with absolute zero.
Manage Clock/Calendar functions and synchronize with external source			

Manage Clock / Calendar functions and synchronize with External Source	4.1.3	Required	▯ BSP RTC driver shall automatically update the RTC with the OST time once per second with an accuracy of 0.1 seconds ▯ Successive interruptions (e.g. on for 5 minutes, off for 3 minutes over a period of 8 hours) shall not introduce cumulative error
Configure and Verify Parameters	3.5.1.4 4.1.4	Required	
Upload/Download blocks of data	3.5.1.5 4.1.5	Required	
Monitor & Verify Application Status	3.5.1.6 4.1.6	Required	
Operator Control of Application Execution	3.5.1.7 4.1.7	Required	Only a local operator is allowed to manage the starting, stopping and scheduling of one or more applications on the ATC.
Operator Control of Application Execution	3.5.1.8		
Long Term Storage of Log Data, etc	4.1.8	Required	
Support Diagnostics	3.5.3.3 4.3.4	Required	
Modes of Operation	3.7	Required	(Must support Standalone, Direct, and Distributed modes of operation)
Manage/Control a Variety of External Devices	4.2.1	Required	▯ Fixed Ports on the front panel shall be specified by the City ▯ Only SP1 and SP2 are required to be supported on the modem slot ▯ The dedicated synchronous serial port (SP5) is to be used exclusively for supporting a parallel I/O module (NEMA TS2 or legacy interface)
Monitor the Status of External Devices	4.2.2	Required	▯ Fixed Ports on the front panel shall be specified by the City ▯ Only SP1 and SP2 and required to be supported on the modem slot ▯ The dedicated synchronous

			serial port (SP5) is to be used exclusively for supporting a parallel I/O module (NEMA TS2 or legacy interface)
Support future Hardware Upgrades	4.3.2	Required	
Environmental Requirements	5.2.3	Required	
Front Panel Serial Ports	6.2.3.1 6.1.3 6.3.2.1	Required	One serial port on the front panel shall satisfy this section as an EIA-574 (9-pin) and be labeled “Port 2”.
Front Panel Serial Ports	6.2.3.1 6.3.2.1	Required	One serial port shall satisfy this section as an EIA-574 (9-pin) with a reduced pin-out (TXD, RXD, and DC Reference at a minimum) and be labeled “C50S”. C50_ENABLE shall not be supported. A second serial port shall fully satisfy this section as an EIA-574 (9-pin) and be labeled Port 3.
Front Panel Serial Ports	6.2.3.2 6.1.3 6.3.2.2	Required	One serial port shall satisfy this section as an EIA-485 (15-pin) with the TS2 Type 1 Port 1 pin-out and be labeled “Port 1”.
Front Panel Ethernet Ports	6.2.3.9 6.3.2.9 7.1.4.4	Required	There shall be a minimum of two Ethernet ports on the Front Panel (one for ENET1, one for ENET2)
User Interface	7.1 7.1.1.2 7.1.4.4 7.1.4.5 7.1.4.7	Required	(See “Port 2” under “Front Panel Serial Ports”)
User Interface	7.1.1	Required	Must meet City’s Minimum requirements
User Interface	7.1.1.1 7.1.2.1 7.1.3 7.1.4.1 7.1.5	Required	- Data key is not required - Front Panel Interface is to be integral to the controller (i.e. not removable, no SP6 connector) - “Option 1” to be selected but AUX switch is optional - Keypad shall have a minimum of 24 keys - LCD Display shall be graphical with a minimum resolution of

			128 rows x 240 columns (up to 16 lines x 40 characters). - LCD pixel size shall be a minimum of 0.32mm x 0.32mm with a minimum pitch of 0.325mm with character size defined as 6 pixels wide x 8 pixels high - Refresh rate is a minimum of 10 times per second (due to larger display requirements) - LCD heater is mandatory to ensure sub-second LCD display response over full temperature range. Heater shall only be active when needed and User is interacting with the controller locally (due to battery backup requirements). - Heater Power shall be up to 15V at 1A current maximum
		Required	As applicable for NEMA cabinets only
Power Supply	7.2 7.2.1 7.2.2 7.2.3 7.2.4 7.2.5 7.2.5.1 7.2.5.2 7.2.6.1 7.2.6.2 7.2.6.3 7.2.6.4 7.2.6.6		
Power Supply	7.2.6 7.2.6.5	Required	- Optional Display (LCD) Heater is required - 24VDC, 12VDC, and -12VDC shall also satisfy the holdup time requirements within their respective output specifications
Mechanical/Chassis	7.3.1.3	Required	- Only Shelf mounted units are

	7.3.1.4	Required	acceptable - Only components / connectors specified by the City shall be located on either the Front or Rear panels. No C1 Type Connectors allowed
I/O Interfaces	8.1.1 8.2.2 8.2.2.1 8.2.2.2 8.2.2.3 8.2.2.4 8.4 8.4.1 8.4.2 8.4.3 8.5		- Support for TS2 Type 2 and TS1 Interfaces - Only provided Ethernet ports shall be subject to ESD requirements
I/O Interfaces	8.1.2 8.2.2.5	Required	- Support is only required for NEMA TS2 Type 2, TS1, and other similar legacy interfaces - NEMA TS2 Port 1 shall also be provided (for detectors only)
I/O Interfaces	8.2.3	Required	Port 1 Connector shall be provided as specified within this section (only used for detectors)
I/O Interfaces	8.2.1.13	Required	Legacy I/O interfaces shall respond as required.
I/O Interfaces not required	8.2.1	Required	- No support for Model 332 Cabinets or ITS Cabinets & devices is to be provided
Serial I/O	8.3	Required	- Only two Ethernet ports are required and they shall be located on the Front Panel (one for ENET1, one for ENET2) - If Hub1 is provided, it shall have **three** external RJ-45 jacks and also connect to the Modem slot along with ENET1 on the Engine Board - Hub2 is not required - Serial Port Usage is as follows:

			○ SP1: Modem Slot & NEMA Port 3 (front) as TIA-574 instead of FSK ○ SP2: Modem Slot ○ SP3: TS2 Port 1 ○ SP5: TS2 Parallel I/O ○ SP6: Integrated User Interface (i.e. no external connector) ○ SP8: EIA-574 (front) as TS2 Port 2 (but with ATC v5.2b limited pins) ○ SPI: No external interface ○ USB: USB port (front) ○ ENET1: At least 1 RJ45 ○ ENET2: At least 1 RJ45
Environmental & Test Procedures	9	Required	All subsections are required
Performance & Material Requirements	10	Required	All subsections are required
Performance & Material Requirements	10.1.15	Required	All PCBs and similar construction mechanisms shall be mounted vertically (i.e. no horizontal PCBs are allowed).
Quality Control	11	Required	All subsections are required

ELECTRICAL SPECIFICATION 1584
DIVISION OF ELECTRICAL OPERATIONS
DEPARTMENT OF TRANSPORTATION
CITY OF CHICAGO
JANUARY 14, 2014

LUMINAIRE: COBRA-HEAD, ARTERIAL, LED (400 WATT LAMP HPS EQUIVALENT), IES CUTOFF TYPE II/III DISTRIBUTION

SUBJECT

1. This specification states the requirements for an LED street lighting luminaire with driver. The luminaire shall be equivalent to a luminaire with a 400 watt HPS lamp and an IES Type II/III medium cutoff distribution. The overall shape of the luminaire shall be the cobra-head as presently used by the City for arterial streets.

GENERAL

2. (a) Information Required. Each bidder shall submit with his proposal the following information relative to the luminaire he proposes to furnish:

1. Outline drawing.
2. Complete description and weight.
3. Candlepower distribution curve showing the light distribution in the 70º degree cone and in a vertical plane through the maximum beam.
4. Isolux curves.
5. Utilization efficiency charts.
6. Luminaire efficiency.
7. Projected area in square feet.
8. Manufacturer's name and catalogue designation of the luminaire.
13. IES formatted photometric curve in electronic format.

(b) Sample. One completely assembled luminaire of the manufacture intended to be furnished, must be submitted upon request of the Chief Procurement Officer within fifteen (15) business days of such request.

(c) Assembly. Each luminaire must be delivered completely assembled, wired, and ready for installation. It must consist of aluminum die-cast housing, LED arrays, tempered glass refractor, terminal block, driver-door panel, electronic driver, gaskets, slip fitter, photocontrol receptacle (if required) and

all necessary hardware.

(d) Warranty. The manufacturer shall warrant the performance and construction of these luminaires to meet the requirements of this specification, and must warrant all parts, components and appurtenances against defects due to design, workmanship or material developing within a period of ten (10) years from the date of manufacture as indicated on the luminaire. A reduction of lighting output of more than 10% within the ten years will constitute luminaire failure. Any luminaire or part thereof, not performing as required, or developing defects within this period must be replaced by the manufacturer without expense to the City.

(e) Organizations. The following organizations' specifications are mentioned herein.

ANSI – American National Standards Institute
ASTM – American Society for Testing and Materials
IEC – International Electrotechnical Commission
UL – Underwriters Laboratories
IESNA – Illuminating Engineering Society of North America

CONSTRUCTION

3. (a) Weight and Area. The net weight of this luminaire must not be more than 46 pounds. The effective projected area (EPA) must not exceed 1.0 square feet.

(b) Housing. The housing shall be a precision aluminum die-casting composed of aluminum meeting ASTM Specification A380. It must be substantial and adequate enough to withstand the strains likely to be imposed on the housing when installed and in service. The housing must enclose the slipfitter, LED arrays, glass refractor, photocontrol receptacle, terminal board, and the electronic driver, with provision for proper mounting of these parts. The housing must have provision on its top surface to permit leveling with a spirit level. The housing must have integral heat sink characteristics, such that all enclosed components will operate within their designed operating temperatures under expected service conditions. No extra items shall be installed as heat shields or heat sinks. All heat shields and heat sinks shall be integral to the luminaire. The housing will have an appearance similar to existing cobra-head housings typically in use on Chicago's arterial streets.

(c) Slip Fitter. The slip fitter shall be suitable for attachment over the end of a two (2) inch steel pipe with an approved means of clamping it firmly in place, and must provide a cast-in pipe-stop. It may be integral with, or may be attached to, the housing. The slip fitter must be designed to permit

adjustment of not less than five (5) degrees above and below the axis of the mounting bracket. The slip fitter must contain an approved shield around the pipe entrance to block entry of birds.

(d) Refractor. The refractor shall be crystal clear, heat-resistant, tempered glass, well annealed, homogeneous, and free from imperfections and striations. It must be flat.

(e) Refractor Holder. The refractor holder must be die cast of aluminum alloy A380. The refractor must be securely held in the refractor holder with a number of stainless steel screws.

(f) Driver Door-Panel. The driver components must be completely assembled and mounted on a die-cast aluminum door-panel composed of aluminum alloy A380. The door-panel must be hinged to the luminaire housing, suitably latched and fastened at the closing end. It must be made to be removed easily. The hinge and fastening devices must be captive parts which will not become disengaged from the door panel. An adhesive backed vinyl-impregnated cloth marker with an ID designation in 2" high black numbers on a red/white background must be attached to the door. The marker must be identifiable from the ground when the luminaire is mounted at a height of 30 feet.

(g) Gaskets. Wherever necessary, in order to make a completely dustproof optical assembly, gaskets of silicone rubber or other specifically approved material must be provided. The reflector gasket must fit around and over the flange of the reflector.

(h) Hardware. All machine screws, locknuts, pins and set screws necessary to make a firm assembly, and for its secure attachment to the mast arm, must be furnished in place. All hardware must be of stainless steel, copper silicon alloy or other non-corrosive metal, and where necessary must be suitably plated to prevent electrolytic action by contact with aluminum.

(i) Finish. The luminaire shall have a polyester powder coat with a minimum 2.0 mil thickness. Surface texture and paint quality will be subject to approval. Color must be gloss black or gray Munsell No. 5BG 7.0/0.4 (designated A.S.A. No. 70) as specified in the order. A paint chip must be submitted as a sample upon request.

(j) Ingress Protection. The luminaire shall have an ingress protection rating of IP65 or better as described in IEC standard 60529 (also ANSI C136.25-2009).

(k) The luminaire shall be UL listed. It shall be suitable for wet locations per UL 1598.

(l) The luminaire shall be rated to operate between -40° to +50° Centigrade.

(m) The luminaire shall have the option of adding a house side shield.

(n) A bar code with pertinent information for warranty and maintenance shall be attached to the inside of the housing. A separate bar code label shall be on the inside of the driver door.

ELECTRICAL COMPONENTS

4. (a) LED Optical Array. The LED arrays shall be optimized for the required roadway photometrics. The arrays must be properly secured at the factory and must not require field adjustment for optimum photometric performance. The LEDs shall deliver a minimum of 70% of initial lumen output at 50,000 hours. LEDs shall provide a color rendition index (CRI) of 70. The color temperature of the LEDs shall be 4000 degrees Kelvin. The optical unit shall have an IP66 rating.

(b) Terminal Block. A divisible-type terminal block of molded phenolic plastic must be provided within the housing in a readily accessible location on the main housing mounted directly over the driver door. It must be easily accessible when opening the driver door. The terminal block must be rated for 600 volts and must provide the terminals needed to completely prewire all luminaire components. The terminal block must be connected to a quick disconnect so that power to all components can be removed. The terminal block will have plated copper or plated brass, clamp-type pressure terminals of an approved type which will accommodate an incoming wire size of #12 AWG. The terminals for connection of the incoming wiring must be the polarized quick disconnect type.

(c) Driver Requirements:

1. Voltage. The electronic driver shall operate at a nominal input voltage range of between 120 and 277 volts, 60 Hertz.

2. The driver shall provide the proper operating voltage to the LED arrays. Output frequency must be equal to or greater than 120 Hertz to avoid flicker.

3. Power Factor. The power factor of the driver over the design range of input voltages specified above must not be less than 90%.

4. The driver input current must have Total Harmonic Distortion (THD)

of less than 20% when operated at nominal line voltage.

5. The driver must be thermally protected to shut off when operating temperatures reach unacceptable levels.

6. The driver must meet the requirements of the FCC rules and regulations, Title 47 CFR, part 15 and 18.

7. The driver shall have a Class A sound rating per ANSI C63.4.

8. Surge protection. The driver must have internal surge protection of 10kV/5kA per ANSI C62.41.2 - 2002.

9. The standard drive current shall be 525mA.

(d) The off-state power consumption of the luminaire shall not exceed 2.5 watts.

(e) The minimum luminaire efficacy shall be 80 lumens per watt.

(f) Mounting. The driver shall be mounted and fastened on the driver door in a manner such that the driver will remain secure and capable of withstanding the vibrations and shocks likely to occur when installed and in service. The driver must be readily removable for replacement.

(g) Wiring. All components must be completely factory wired with non-fading, color coded leads. These leads must be insulated with an approved class of insulation and must be #16 AWG conductor minimum. All wires within a single circuit path must be of the same size. No wire nuts will be allowed. No unnecessary splices will be allowed. The use of wiring smaller than #16 AWG will require the written approval of the Commissioner. Color coding will be in a manner approved by the Commissioner. A complete wiring diagram must be displayed at an approved location on the interior of the luminaire and must include all luminaire and component identification and ratings. The wiring diagram must be provided on high quality material that will be resistant to cracking, yellowing, and fading in a luminaire environment. Quick disconnects must be provided for all components.

(h) Option:Photo-control Receptacle and Cap. If the contract calls for photo-control, a standard three-prong, twist lock receptacle for a photo-control meeting ANSI standard C136.10 must be mounted in the housing with provision for proper positioning of the photo-control. The receptacle must be able to be repositioned without the use of tools. The photo- control is not required to be furnished, but a shorting cap with a three-prong plug having line-load prongs shorted together and meeting ANSI standard C136.10 must be provided. If the contract calls for no photo-control capability, a shorting cap must be provided.

(i) Component Mounting.

1. Modular Construction. All electrical components must be securely mounted in such manner that individual components can be easily maintained or replaced. Permanent straps or tie-wraps will not be permitted. The entire assembly should be easily disconnected and removed for replacement.

2. Interchangeability. Components must be mutually field interchangeable so that units can be restored to working condition without trouble shooting components.

PHOTOMETRIC REQUIREMENTS

5. (a) The manufacturer must demonstrate that the luminaires will meet or exceed the specified photometric requirements. The manufacturer must provide photometric calculations using published luminaire data as part of the submitted package. The proposal must contain luminaire photometric performance with results equal to or better than those listed in this specification. Submittal information must include computer calculations based on the controlling given conditions which demonstrate achievement of all listed performance requirements. Computer calculations must be performed for roadway lighting and for sidewalk/parkway lighting. The submitted roadway lighting calculations must be done in accordance with I.E.S. RP-8-00, and must include point-by-point illuminance, luminance and veiling luminance as well as listings of all indicated averages and ratios. The submitted sidewalk/parkway calculations must be done in accordance with I.E.S. RP-8-00, and must include point-by-point horizontal illuminance and vertical illuminance as well as listings of all indicated averages and ratios.

(b) Unless otherwise indicated, the light distribution will be I.E.S. classified as medium-cutoff-Type II/III (M-C-II/III), as defined in the "American National Standard Practice for Roadway Lighting" approved June 27, 2000 by the "American National Standards Institute" (ANSI).

(c) Performance Requirements (0.7 light loss factor):

1. Roadway Illuminance:
   Average Horizontal 1.7 fc
   Uniformity Ratio Av/Min 3:1

2. Roadway Luminance:
   Average Luminance 1.2 cd/m2

Uniformity Ratio Av/Min	3:1
Uniformity Ratio Max/Min	5:1
Max Veiling Luminance	0.3

(d) The photometrics shall be run for the specific requirements. If the luminaires are to be obtained for no specific project, the luminaires must meet the performance requirements for the following physical conditions:

Right-of-way	100’
Curb-to-curb	80’
Mounting height	30’
Setback	3’
Arm length	8’
Sidewalk width	6’
Parkway width	4’
Spacing (opposite)	120’
Pavement	R3

TESTING

6. (a) Testing. All testing must be done on a prototype of the actual luminaire to be provided under this specification. If recent test results are available, they may be considered as meeting the testing requirements of this specification. The Commissioner or Commissioner’s representative will have the final approval of which tests are adequate.

(b) The manufacturer will be responsible for all costs associated with the specified testing, incidental to this contract.

(c) Photometric testing must be in accordance with IES recommendations. The tests, at a minimum, must yield:

1. An isofootcandle chart with maximum candela and half maximum candela trace.
2. An isocandela diagram.
3. Maximum plane and maximum cone plots of candela.
4. A candlepower table (house and street side).
5. A coefficient of utilization chart.
6. A luminous flux distribution table.

(d) The luminaire must meet the electrical and photometric requirements of IESNA LM -79.

(e) The luminaire must meet the lumen maintenance requirements of IESNA LM -80.

(f) The luminaire must meet the requirements of IESNA TM -21 for long term maintenance of LED light sources.

(g) The LEDs must meet the requirements for chromaticity per ANSI C78.377.

(h) The following applicable UL standards shall be met:

1. 8750 LED Light Sources in Lighting Products
2. 1598 Luminaires
3. 1012 power units other than Class 2
4. 1310 Class 2 power units
5. 2108 low voltage lighting systems

(i) Additional Types of Testing.

1. Interchangeability of all component parts.
2. Thermal testing in accordance with U.L. Standard 1572 or Standard 1598. The fixture must be placed in a controlled 25° Celsius environment and be energized for a minimum of 8 hours. At no time will any of the components exceed the manufacturer's recommended operating temperatures. At no time will any surface of the refractor exceed the manufacturer's recommended temperature limits.
3. 2G vibration testing in accordance with ANSI Standard C136.31. Upon completion of the test, all set screws, castings, and components must be secure and undamaged. The luminaire will not be energized for this test. However, the luminaire must be fully operational after the test.
4. Moisture testing in accordance with U.L. Standard 1572 or Standard 1598. The luminaire will be subjected to a water spray from various directions for a sufficient amount of time. After the water spray the inside of the refractor must remain dry and the fixture should be demonstrated to operate properly.

PACKAGING

7. (a) Packing. Each luminaire assembly must be packed in a suitable carton so secure that it must not be damaged in shipment and handling.

(b) Marking. Each carton containing a luminaire must be clearly marked on the outside in letters not less than three-eighths (3/8) inch tall with the legend: "LUMINAIRE, LED, (400WHPS EQUIVALENT), IES CUTOFF TYPE II/III", the appropriate City Commodity Code Number, the name of the manufacturer, the date of manufacture, and the contract number under which the luminaire is furnished.

THIS SPECIFICATION SHALL NOT BE ALTERED

ELECTRICAL SPECIFICATION 1586
DIVISION OF ENGINEERING
DEPARTMENT OF
TRANSPORTATION
CITY OF CHICAGO
OCTOBER 28, 2014

LUMINAIRE: LED, ORNAMENTAL, ARTERIAL ACORN I.E.S. TYPE II/III DISTRIBUTION

SUBJECT

1. This specification states the requirements for an ornamental Acorn LED street lighting luminaire. The luminaire shall be mounted on a tenon at a mounting height of 16 or 23 feet above grade and have an IES Type II/III medium non-cutoff distribution. The luminaire will be used to provide roadway lighting for arterial streets.

GENERAL

2. (a) Information Required. If so requested, the apparent low bidder shall submit the following information relative to the luminaire he proposes to furnish, within fifteen (15) business days of such request:

    1. Outline drawing.
    2. Complete description and weight.
    3. Luminaire efficiency.
    4. Effective projected area in square feet.
    5. Manufacturer's name and catalogue designation.
    6. Manufacturer's part list.
    7. IES formatted photometric curve in electronic format.
    8. Certified test reports.

(b) Sample. One completely assembled luminaire of the manufacture intended to be furnished shall be submitted upon request of the Chief Procurement Officer within fifteen (15) business days from receipt of notice.

(c) Assembly. Each luminaire must be delivered completely assembled, wired, and ready for installation. The luminaire must consist of the capital and globe as shown on the Electrical Standard Drawing 912, LED optical system as required to meet the photometric requirements of this specification, electronic driver, quick disconnects, terminal board, fusing, gaskets and all necessary hardware.

(d) Warranty. The manufacturer shall warrant the performance and construction

of these luminaires to meet the requirements of this specification, and must warrant all parts, components and appurtenances against defects due to design, workmanship or material developing within a period of ten (10) years from the date of acceptance by the City. A reduction of lighting output of more than 30% within the ten years will constitute luminaire failure. Any luminaire or part thereof, not performing as required, or developing defects within this period must be replaced by a new luminaire, delivered to the City by the manufacturer, without expense to the City. The Commissioner will be the sole judge in determining which replacements are to be made and his decision will be final.

(e) The manufacturer shall have a history of manufacturing roadway and outside area lighting for a minimum of five years. The manufacturer must demonstrate to the City that the manufacturer has the capacity to supply the quantities required for the contract in a timely manner.

(f) Organizations. The following organizations' specifications are mentioned herein.

ANSI – American National Standards Institute
ASTM – American Society for Testing and Materials
IEC – International Electrotechnical Commission
IES – Illuminating Engineering Society
UL – Underwriters Laboratories

CAPITAL AND FINIAL

3. (a) Material. Each capital and finial shall be cast aluminum conforming to American Die casting Standard ADC-1-C9-83 grade 380.

(b) Appearance. The capital shall conform in appearance to that shown on Electrical Standard Drawing Number 912.

(c) Construction. Castings must have smooth external surfaces free from protuberances, dents, cracks or other imperfections marring their appearance. Welding or plugging of casting defects is prohibited.

(d) Structural Integrity. The capital shall fit over a 3" high by 3" O.D. tenon. The capital attachment to the tenon shall provide the structural integrity to hold the luminaire firmly in place during the vibrations anticipated due to passing heavily loaded vehicles, wind loading, and inclement weather. A minimum of 3/16" thickness of metal must be provided where the set screws are inserted to minimize the possibility of stripping the threads when the set screws are tightened into place. The set screws must be 5/16-18 stainless steel hex head screws. A minimum of three (3) set screws must be provided, evenly spaced at 120° apart. The finial shall be securely attached to the acorn

globe such that it will remain in place during the vibrations described above.

CAPITAL AND FINIAL PAINTING

4. (a) Oil and Grease Removal. All metal surfaces shall be washed with an alkaline detergent to remove any oils or grease.

(b) Chemical Pretreatment. The cleaned metal surfaces must then be treated with a hot, pressurized phosphate wash and must be dried by convection heat.

(c) Exterior and Interior Coat. A thermosetting, weathering, Polyester powder coat shall be applied electrostatically to all cleaned and treated surfaces to a uniform four-mil(4.0) thickness in a one coat application. This powder coat must be cured in a convection oven at a minimum temperature of 400º Fahrenheit to form a high molecular weight fusion bonded finish.

(d) Alternate Methods. Alternate powder coat methods may be reviewed and tested on a case-by-case basis. However, no coating method will be accepted unless the Commissioner judges such alternate to be equal to the coating herein specified.

(e) Durability. Both the exterior and interior coats shall be capable of passing 1,000 hours of salt spray exposure as per ASTM B117 in a 5% Na Cl (by weight) solution at 95º Fahrenheit and 95% relative humidity without blistering. Before test, the panel must be scribed with an "X" down to the bare metal.

(f) Coating Measurement. Measurement of coating thickness shall be done in accordance with SSPC-PA 2-73T, "Measurement of Dry Paint Thickness with Magnetic Gauges," except that the lowest "single spot measurement" in an area of two square inches must be not less than 3.0 mils.

(g) Color. Color shall be gloss black. A color sample must be submitted for approval prior to fabrication. This color sample must include the manufacturer's name and the manufacturer's color name as well as any other information which will be required to purchase the same color for the masts, mast arms, and split pedestal bases.

COMPONENT MOUNTING

5. (a) Modular Construction. All electrical components shall be securely mounted by means of easily removable stainless steel captive thumb screws or by easily operated stainless steel latches. No tools shall be necessary to remove components. Provision shall be made to allow easy access to quick disconnects, terminal blocks and components for installation and maintenance.

(b) Quick Disconnect. Wiring from the terminal block to the components on the mounting plate must utilize a three (3) conductor, phenolic, polarized, quick disconnect device.

(c) Interchangeability. Component mounting plates must be mutually field interchangeable so that units can be restored to working condition without trouble shooting components.

(d) Other Methods. Other methods of component mounting may be considered if they are judged to provide the same ease of installation and maintainability. No alternates will be allowed without the specific written approval of the Commissioner.

(e) Optional Receptacle. If desired, A 120 Volt, grounded receptacle must be provided in an easily accessible location in the capital. It must be separately wired to its own polarized quick disconnect connector. The access door for the component mounting plate must be notched to provide for securing the door with a three wire, #12 AWG, Type S.O. cord plugged into the outlet.

ELECTRICAL COMPONENTS

6. (a) LED Optical Array. The LED arrays shall be optimized for the required roadway photometrics. The arrays must be properly secured at the factory and must not require field adjustment for optimum photometric performance. The LEDs shall deliver a minimum of 70% of initial lumen output at 100,000 hours (L70 at 100K). LEDs shall provide a color rendition index (CRI) of 70. The color temperature of the LEDs shall be 4000 degrees Kelvin. The optical unit shall have an IP66 rating.

(b) Terminal Block, Fusing, and Wiring. A barrier type terminal board of molded phenolic plastic shall be mounted to the capital in a readily accessible location. The terminal block must have plated copper or plated brass, clamp type pressure terminals of an approved type which will accommodate incoming wire sizes ranging from #12 AWG to #8 AWG. The luminaire must be prewired from the terminal block to and including the electrical components. Two in-line fuse holders will be wired from the terminal to a quick disconnect; the wiring will continue from the quick disconnect to the components mounted on the plate. By disconnecting the quick disconnect, the electrical components on the mounting plate may be removed as a unit, and easily replaced. The in-line fuse holders must accommodate KTK fuses rated for 10Amp, 600VAC, and 100,1000AMP interrupting capacity. The fuses must be included. In lieu of in-line fuses, a fuse block must be provided which will accommodate the same size fuses.

(c) Driver Requirements:

1. Voltage. The electronic driver shall operate at a nominal input voltage range of between 120 and 277 volts, 60 Hertz.

2. The driver shall provide the proper operating voltage to the LED arrays. Output frequency must be equal to or greater than 120 Hertz to avoid flicker.

3. Power Factor. The power factor of the driver over the design range of input voltages specified above must not be less than 90%.

4. The driver input current must have Total Harmonic Distortion (THD) of less than 20% when operated at nominal line voltage.

5. The driver must be thermally protected to shut off when operating temperatures reach unacceptable levels.

6. The driver shall be short circuit protected and over load protected.

7. The driver must meet the EMI (electromagnetic interference) requirements of the FCC rules and regulations, Title 47 CFR, part 15 and 18.

8. The driver shall have a Class A sound rating per ANSI C63.4.

9. The drive current shall be as recommended by the LED manufacturer. The current level should be such that the LEDs are not overdriven or underdriven. LED current should produce the most efficient light output without compromising the life of the LEDs.

(d) Surge Protection. Surge protection shall be 10kV/10kA per ANSI C62.41.2. The surge protection device shall be a 3 wire device. The suppressor shall be NRTL listed and be in accordance to UL 1449.

(e) The minimum luminaire efficacy shall be 90 lumens per watt.

(f) Mounting. The driver shall be mounted in a manner such that the driver will remain secure and capable of withstanding the vibrations and shocks likely to occur when installed and in service. The driver must be readily removable for replacement.

(g) Wiring. The LED array and driver components must be completely factory wired with non-fading, color coded leads. These leads must be insulated with an approved class of insulation and must be #16 AWG conductor minimum. The use of wiring smaller than #16 AWG will require the written approval of the Commissioner. Color coding will be in a manner approved

by the Commissioner. All wires within a single circuit path must be of the same size. No wire nuts will be allowed. No unnecessary splices will be allowed. A complete wiring diagram must be displayed at an approved location on the interior of the luminaire and must include all luminaire and component identification and ratings. The wiring diagram must be provided on high quality material that will be resistant to cracking, yellowing, and fading in a luminaire environment. Quick disconnects must be provided for all components.

ACORN GLOBE AND REFLECTOR

7. (a) Appearance. Globe shall conform to that shown on Electrical Standard Drawing 912.

(b) Material/Construction. Globe shall be constructed of clear, V825 HID acrylic utilizing a slip-fit 1/2" overlap, two piece which eliminates a "butt-glue" seam appearance.

The bottom optical section of the globe must have a neck opening of 7-1/4" at the smallest diameter and an outside dimension of 8" at the bottom; be a minimum of 12-3/4" in height and 16 1/2" in width at the top.

The top section of the globe must be "Victorian" in appearance; a minimum of 13" in height and 16.313" in width with 100 horizontal prisms to evenly diffuse light. If so requested, a full top reflector of the same diameter as the globe shall be installed between the halves and secured to the globe. The top and bottom sections shall be secured in a slip-fit overlap design using four #10 -24 x 5/8 stainless steel pan head screws with four aluminum nutserts providing a mechanical lock. In addition, a sealant must be applied to the two halves to provide a dust-proof seal.

(c) Globe Mounting. The globe shall be mounted with four 5/16-18 hex head, stainless steel bolts with stop nuts mounted into the die cast fixture housing. They must securely contact an aluminum globe neck ring connected to the acorn globe. The globe must be clearly marked and keyed so that it will be properly installed to provide the required house side/street side photometrics. The mounting must afford the rigidity necessary to prevent the globe from twisting or rattling when subjected to the vibrating forces of passing elevated trains or heavily loaded vehicles. The mounting must not preclude any globe from being mutually interchangeable with any other globe intended for this function.

(d) Reflectors. A top reflector and a house-side reflector shall be provided. These reflectors shall be mounted to a removable bracket. The small dome shaped top reflector, approximately 6.5 inches in diameter and 3 inches deep

shall be mounted on the bracket and attached by a spring clamp, or other suitable means, to the lamp socket or lamp socket holder. The side reflector shall be mounted to the same bracket. The reflectors shall be constructed of aluminum and polished to a high specular finish. Reflectance of the reflecting surfaces shall not be less than 75%. Measurements shall be made with a reflectometer using the fiber-optic method.

(e) Optional Reflector. If so ordered in the line item of a contract, a full top reflector will be provided as part of the globe. This reflector will be inserted between the two halves of the globe and permanently sealed to the globe halves. This reflector will not allow any light from the lamp to enter the top half of the globe.

PHOTOMETRIC REQUIREMENTS

8. (a) The manufacturer must demonstrate that the luminaire shall meet or exceed the specified photometric requirements. The manufacturer must provide photometric calculations using published luminaire data as part of the submitted package. Submittal information must include computer calculations which demonstrate achievement of all listed performance requirements. Computer calculations must be performed for roadway lighting and for sidewalk/parkway lighting. The submitted roadway lighting calculations must be done in accordance with I.E.S. RP-8-14, and must include point-by-point illuminance and luminance, as well as listings of all indicated averages and ratios. The submitted sidewalk/parkway calculations must be done in accordance with I.E.S. RP-8-14, and must include point-by-point horizontal illuminance and vertical illuminance, as well as listings of all indicated averages and ratios.

(b) Unless otherwise indicated, the light distribution will be classified as medium-non-cutoff-Type II or Type III (M-N-II or M-N-III), as defined in Appendix E of I.E.S. RP-8-14.

(c) Performance Requirements (0.7 light loss factor):

Roadway Illuminance:

Average Horizontal	1.7 fc
Uniformity Ratio Av/Min	3:1

Roadway Luminance:

Average Luminance	1.2 cd/m2
Uniformity Ratio Av/Min	3:1
Uniformity Ratio Max/Min	5:1
Max Veiling Luminance	0.5

(d) The photometrics shall be run for the specific project requirements. If the luminaires are to be obtained for no specific project, the luminaires must meet the performance requirements for the following physical conditions.

Right of way	80’
Curb-to-curb	48’
Mounting height	23’
Setback	4’
Arm length	0’
Spacing (opposite)	75’
Pavement	R3

TESTING

9. (a) Testing. All testing must be done on a prototype of the actual luminaire to be provided under this specification. If recent test results are available, they may be considered as meeting the testing requirements of this specification. The Commissioner or Commissioner’s representative will have the final approval of which tests are adequate.

(b) The manufacturer will be responsible for all costs associated with the specified testing, incidental to this contract.

(c) Photometric testing must be in accordance with IES recommendations. The photometric tests must be conducted with a reference lamp and ballast. The tests, at a minimum, must yield:

1. An isofootcandle chart with maximum candela and half maximum candela trace.
2. An isocandela diagram.
3. Maximum plane and maximum cone plots of candela.
4. A candlepower table (house and street side).
5. A coefficient of utilization chart.
6. A luminous flux distribution table.

(d) The luminaire must meet the electrical and photometric requirements of IESNA LM -79.

(e) The luminaire must meet the lumen maintenance requirements of IESNA LM -80.

(f) The luminaire must meet the requirements of IESNA TM -21 for long term maintenance of LED light sources.

(g) The LEDs must meet the requirements for chromaticity per ANSI C78.377.

(h) The following applicable UL standards shall be met:

1. 8750 LED Light Sources in Lighting Products
2. 1598 Luminaires
3. 1012 power units other than Class 2
4. 1310 Class 2 power units
5. 2108 low voltage lighting systems

(i) Additional Types of Testing.

1. Interchangeability of all component parts.

2. Thermal testing in accordance with U.L. Standard 1572 or Standard 1598. The fixture must be placed in a controlled 25° Celsius environment and be energized for a minimum of 8 hours. At no time will any of the components exceed the manufacturer's recommended operating temperatures. At no time will any surface of the refractor exceed the manufacturer's recommended temperature limits.

3. Vibration testing in accordance with ANSI Standard C136.31. Upon completion of the test, all set screws, castings, and components must be secure and undamaged. The luminaire will not be energized during the test, and will not include the LED's and fuses. However, the luminaire must be fully operational after the test.

4. Moisture testing in accordance with U.L. Standard 1572 or Standard 1598. The luminaire will be subjected to a water spray from various directions for a sufficient amount of time to verify that the inside lamp compartment stays dry and that the fixture does not take on water. After the water spray the inside of the refractor must remain dry and the fixture should be demonstrated to operate properly.

PACKAGING

10. (a) Packing. Each luminaire assembly must be securely packed in a suitable carton so that it will not be damaged by shipment and/or handling.

(b) Marking. Each carton containing a luminaire must be clearly marked on the

outside in letters not less than three-eights (3/8) inch tall with the legend:

"ORNAMENTAL, ARTERIAL, ACORN, LED,I.E.S. TYPE II/III". The appropriate City Commodity Code Number, the name of the manufacturer, the date of manufacture, and the contract number under which the luminaire is furnished shall also be listed.

ELECTRICAL SPECIFICATION 1587
DIVISION OF ENGINEERING
DEPARTMENT OF
TRANSPORTATION
CITY OF CHICAGO
MAY 14, 2015

LUMINAIRE: LED, VIADUCT

SUBJECT

1. This specification states the requirements for an LED luminaire complete with driver. The luminaire shall be for underpasses such as railroad viaducts and other elevated structures. The input voltage shall be between 120 and 240 volts. The luminaires shall be mounted to the structures , either directly or mounted to a trunnion type bracket.

GENERAL

2. (a) Information. If so requested, the apparent low bidder shall submit the following information relative to the luminaire he proposes to furnish within fifteen (15) days of such request:

1. Outline drawing.
2. Complete description and weight.
3. Luminaire efficiency.
4. Projected area in square feet.
5. Manufacturer's name and catalogue designation.
6. Manufacturer’s part list.
7. IES formatted photometric curve in electronic format.
8. Certified test reports.

(b) Sample. One completely assembled luminaire of the manufacture intended to be furnished, must be submitted upon request of the Chief Procurement Officer within fifteen (15) business days of such request.

(c) Assembly. Each luminaire must be delivered completely assembled, wired, and ready for installation. It must consist of an aluminum die-cast housing, LED arrays, terminal block, electronic driver, gaskets, surge arrestor, fuses, trunnion bracket, and all necessary hardware.

(d) Warranty. The manufacturer shall warrant the performance and construction of these luminaires to meet the requirements of this specification, and must warrant all parts, components and appurtenances against defects due to

design, workmanship or material developing within a period of ten (10) years from the date of acceptance by the City. A reduction of lighting output of more than 30% within the ten years will constitute luminaire failure. Any luminaire or part thereof, not performing as required, or developing defects within this period must be replaced by a new luminaire, delivered to the City by the manufacturer, without expense to the City. The Commissioner will be the sole judge in determining which replacements are to be made and his decision will be final.

(e) The manufacturer shall have a history of manufacturing roadway and outside area lighting for a minimum of five years. The manufacturer must demonstrate to the City that the manufacturer has the capacity to supply the quantities required for the contract in a timely manner.

(f) Organizations. The following organizations' specifications are mentioned herein.

ANSI – American National Standards Institute
ASTM – American Society for Testing and Materials
IEC – International Electrotechnical Commission
IES – Illuminating Engineering Society
UL – Underwriters Laboratories

CONSTRUCTION

3. (a) Weight and Area. The net weight of this luminaire must not be more than 25 pounds and should be able to be handled by one man.

(b) Housing. The housing shall be a precision aluminum die-casting composed of aluminum meeting ASTM Specification A380. It must be substantial and adequate enough to withstand the strains likely to be imposed on the housing when installed and in service. The housing must enclose the LED arrays, terminal board, surge protector, and the electronic driver, with provision for proper mounting of these parts. The housing must have integral heat sink characteristics, such that all enclosed components will operate within their designed operating temperatures under expected service conditions. No extra items shall be installed as heat shields or heat sinks. All heat shields and heat sinks shall be integral to the luminaire.

The housing shall be designed to allow water shedding. The housing shall be designed to minimize dirt and bug accumulation on the optic surface.

The housing shall be able to be mounted directly to a wall or to be trunnion mounted. There shall be a .75 inch threaded conduit fitting to accommodate an electrical whip.

(c) Mounting bracket. A trunnion type bracket shall be provided. The bracket shall be mounted directly to a wall. The luminaire shall then be attached to the bracket. The bracket will allow the luminaire to be positioned up to 90˚ in either direction from the horizontal. The bracket shall be marked on the outside indicating the degrees of angle. The bracket shall provide for positive locking in the desired position.

(d) Gaskets. Wherever necessary, in order to make a completely dustproof assembly, gaskets of silicone rubber or other specifically approved material must be provided.

(e) Hardware. All machine screws, locknuts, pins and set screws necessary to make a firm assembly, and for its secure attachment to the mast arm, must be furnished in place. All hardware must be of stainless steel, copper silicon alloy or other non-corrosive metal, and where necessary must be suitably plated to prevent electrolytic action by contact with aluminum.

(f) Finish. The luminaire shall have a polyester powder coat with a minimum 2.0 mil thickness. Surface texture and paint quality will be subject to approval. Color must be gloss black or gray (designated ANSI No. 70) as specified in the order. A paint chip must be submitted as a sample upon request. The finish shall pass 1000 hours of salt spray per ASTM B117.

(g) Ingress Protection. The luminaire housing shall have an ingress protection rating of IP54 or better as described in IEC standard 60529 (also ANSI C136.25-2009). The optical system shall have an IP66 rating.

(h) The luminaire shall be UL listed. It shall be suitable for wet locations per UL 1598.

(i) The luminaire shall be rated to operate between -40° to +50° Centigrade.

(j) A bar code with pertinent information for warranty and maintenance shall be attached to the inside of the housing.

ELECTRICAL COMPONENTS

4. (a) LED Optical Array. The LED arrays shall be optimized for the required roadway photometrics. The arrays must be properly secured at the factory and must not require field adjustment for optimum photometric performance. The LEDs shall deliver a minimum of 70% of initial lumen output at 100,000 hours (L70 at 100K). LEDs shall provide a color rendition index

(CRI) of 70. The color temperature of the LEDs shall be 4000˚ Kelvin. The optical unit shall have an IP66 rating.

(b) Terminal Board-Fuse Block. A terminal block of high grade molded plastic of the barrier or safety type must be mounted within the housing in a readily accessible location. It must provide all terminals needed to completely prewire all luminaire components. The terminal block must either incorporate a barrier isolated section with fuse clips to take a "small-dimension" cartridge fuse, or a separate barrier protected fuse block must be provided. It must be UL and CSA certified.

The fuses shall be rated at 10 amps 600 VAC with a 100,000 AMPS interrupting capacity. Fuses shall be Buss type KTK, or equal. The fuse block must be wired to the appropriate terminals. The terminal board-fuse block must have plated copper or plated brass, clamp-type pressure terminals of an approved type for "line" connections, to accommodate wire sizes from #12 to #8 A.W.G. The terminals for connection of internal components must be either the screw-clamp or quick disconnect type.

(c) Driver Requirements:

1. Voltage. The electronic driver shall operate at a nominal input voltage range of between 120 and 277 volts, 60 Hertz.

2. The driver shall provide the proper operating voltage to the LED arrays. Output frequency must be equal to or greater than 120 Hertz to avoid flicker.

3. Power Factor. The power factor of the driver over the design range of input voltages specified above must not be less than 90%.

4. The driver input current must have Total Harmonic Distortion (THD) of less than 20% when operated at nominal line voltage.

5. The driver must be thermally protected to shut off when operating temperatures reach unacceptable levels.

6. The driver shall be short circuit protected and overload protected.

7. The driver must meet the EMI (electromagnetic interference) requirements of the FCC rules and regulations, Title 47 CFR, Part 15.

8. The driver shall have a Class A sound rating per ANSI C63.4.

9. Transient voltage complies with ANSI C62.41 Category A.

10. The current should be as recommended by the LED manufacturer. The current level should be such that the LEDs are not overdriven or underdriven. LED current should produce the most efficient light output without compromising the life of the LEDs.

(d) Surge Protection. Surge protection shall be 10kV/10kA per ANSI C62.41.2. The surge protection device shall be a 3 wire device. The suppressor shall be NRTL listed and be in accordance with UL 1449.

(e) The minimum luminaire efficacy shall be 90 lumens per watt.

(f) Wiring. All components must be completely factory wired with non-fading, color coded leads. These leads must be insulated with an approved class of insulation and must be #16 AWG conductor minimum. All wires within a single circuit path must be of the same size. No wire nuts will be allowed. No unnecessary splices will be allowed. The use of wiring smaller than #16 AWG will require the written approval of the Commissioner. Color coding will be in a manner approved by the Commissioner. A complete wiring diagram must be displayed at an approved location on the interior of the luminaire and must include all luminaire and component identification and ratings. The wiring diagram must be provided on high quality material that will be resistant to cracking, yellowing, and fading in a luminaire environment. Quick disconnects must be provided for all components.

(g) Component Mounting.

1. Modular Construction. All electrical components must be securely mounted in such manner that individual components can be easily maintained or replaced. Permanent straps or tie-wraps will not be permitted. The entire assembly should be easily disconnected and removed for replacement.

2. Interchangeability. Components must be mutually field interchangeable so that units can be restored to working condition without trouble shooting components.

PHOTOMETRIC REQUIREMENTS

5. (a) The manufacturer must demonstrate that the luminaires will meet or exceed the specified photometric requirements. The manufacturer must provide photometric calculations using published luminaire data as part of the submitted package. The proposal must contain luminaire photometric performance with results equal to or better than those listed in this

specification. Submittal information must include computer calculations based on the controlling given conditions which demonstrate achievement of all listed performance requirements. Computer calculations must be performed for roadway lighting and for sidewalk lighting. The submitted roadway lighting calculations must be done in accordance with I.E.S. RP-8-14, and must include point-by-point illuminance, luminance and veiling luminance as well as listings of all indicated averages and ratios. The submitted sidewalk calculations must be done in accordance with I.E.S. RP-8-14, and must include point-by-point horizontal illuminance and vertical illuminance as well as listings of all indicated averages and ratios.

(b) Unless otherwise indicated, the light distribution will be classified as short non-cutoff-Type II (S-NC-II), as defined in Appendix E of I.E.S. RP-8-14.

(c) Performance Requirements (0.6 light loss factor):

1. Roadway Illuminance:

Average Horizontal	4.5 fc
Uniformity Ratio Av/Min	3:1

2. Roadway Luminance:

Average Luminance	2.5 cd/m2
Uniformity Ratio Av/Min	3:1
Uniformity Ratio Max/Min	5:1
Max Veiling Luminance	0.5

(d) The photometrics shall be run for the specific requirements. If the luminaires are to be obtained for no specific project, the luminaires must meet the performance requirements for the following physical conditions:

Right-of-way	66’
Curb-to-curb	46’
Mounting height	13’
Tilt	45°
Setback	10’
Arm length	1’
Sidewalk width	10’
Spacing (opposite)	30’
Pavement	R3

TESTING

6. (a) Testing. All testing must be done on a prototype of the actual luminaire to be provided under this specification. If recent test results are available, they may be considered as meeting the testing requirements of this specification. The Commissioner or Commissioner's representative will have the final approval of which tests are adequate.

(b) The manufacturer will be responsible for all costs associated with the specified testing, incidental to this contract.

(c) Photometric testing must be in accordance with IES recommendations. The tests, at a minimum, must yield:

1. An isofootcandle chart with maximum candela and half maximum candela trace.
2. An isocandela diagram.
3. Maximum plane and maximum cone plots of candela.
4. A candlepower table (house and street side).
5. A coefficient of utilization chart.
6. A luminous flux distribution table.

(d) The luminaire must meet the electrical and photometric requirements of IESNA LM -79.

(e) The luminaire must meet the lumen maintenance requirements of IESNA LM -80.

(f) The luminaire must meet the requirements of IESNA TM -21 for long term maintenance of LED light sources.

(g) The LEDs must meet the requirements for chromaticity per ANSI C78.377.

(h) The following applicable UL standards shall be met:

1. 8750 LED Light Sources in Lighting Products
2. 1598 Luminaires
3. 1012 power units other than Class 2
4. 1310 Class 2 power units
5. 2108 low voltage lighting systems

(i) Additional Types of Testing.

1. Interchangeability of all component parts.

2. Thermal testing in accordance with U.L. Standard 1572 or Standard 1598. The fixture must be placed in a controlled 25° Celsius environment and be energized for a minimum of 8 hours. At no time will any of the components exceed the manufacturer's recommended operating temperatures. At no time will any surface of the refractor exceed the manufacturer's recommended temperature limits.

3. Vibration testing in accordance with ANSI Standard C136.31. Upon completion of the test, all set screws, castings, and components must be secure and undamaged. The luminaire will not be energized for this test. However, the luminaire must be fully operational after the test.

4. Moisture testing in accordance with U.L. Standard 1572 or Standard 1598. The luminaire will be subjected to a water spray from various directions for a sufficient amount of time. After the water spray the inside of the refractor must remain dry and the fixture should be demonstrated to operate properly.

PACKAGING

7. (a) Packing. Each luminaire assembly must be packed in a suitable carton so secure that it must not be damaged in shipment and handling.

(b) Marking. Each carton containing a luminaire must be clearly marked on the outside in letters not less than three-eighths (3/8) inch tall with the legend: "LUMINAIRE, LED, VIADUCT". The appropriate City Commodity Code Number, the name of the manufacturer, the date of manufacture, and the contract number under which the luminaire is furnished shall also be listed.

ELECTRICAL SPECIFICATION 1595
DIVISION OF ENGINEERING
DEPARTMENT OF
TRANSPORTATION
CITY OF CHICAGO
REVISED MAY 14, 2015

LUMINAIRE: LED, COBRA-HEAD, ALLEY, IES CUTOFF TYPE I/II DISTRIBUTION

SUBJECT

1. This specification states the requirements for an LED street lighting luminaire complete with driver. The luminaire shall be for alley lighting with an IES Type I/II medium cutoff distribution. The luminaire shall be mounted approximately 18 feet above grade. The overall shape of the luminaire shall be the cobra-head as presently used by the City.

GENERAL

2. (a) Information. If so requested, the apparent low bidder shall submit the following information relative to the luminaire he proposes to furnish within fifteen (15) business days of such request:

1. Outline drawing.
2. Complete description and weight.
3. Luminaire efficiency.
4. Projected area in square feet.
5. Manufacturer's name and catalogue designation of the luminaire.
6. Manufacturer’s parts list.
7. IES formatted photometric curve in electronic format.
8. Certified test results.

(b) Sample. One completely assembled luminaire of the manufacture intended to be furnished, must be submitted upon request of the Chief Procurement Officer within fifteen (15) business days of such request.

(c) Assembly. Each luminaire must be delivered completely assembled, wired, and ready for installation. It must consist of aluminum die-cast housing, LED arrays, terminal block, driver-door panel, electronic driver, gaskets, surge arrestor, fuses, slip fitter, photo-control receptacle and all necessary hardware.

(d) Warranty. The manufacturer shall warrant the performance and construction

of these luminaires to meet the requirements of this specification, and must warrant all parts, components and appurtenances against defects due to design, workmanship or material developing within a period of ten (10) years from the date of acceptance by the City. A reduction of lighting output of more than 30% within the ten years will constitute luminaire failure. Any luminaire or part thereof, not performing as required, or developing defects within this period must be replaced by a new luminaire, delivered to the City by the manufacturer, without expense to the City. The Commissioner shall be the sole judge in determining which luminaires need to be replaced.

(e) The manufacturer shall have a history of manufacturing roadway and outside area lighting for a minimum of five years. The manufacturer must demonstrate to the City that the manufacturer has the capacity to supply the quantities required for the contract in a timely manner.

(f) Organizations. The following organizations' specifications are mentioned herein.

ANSI – American National Standards Institute
ASTM – American Society for Testing and Materials
IEC – International Electrotechnical Commission
IES – Illuminating Engineering Society
UL – Underwriters Laboratories

CONSTRUCTION

3. (a) Weight and Area. The weight of this luminaire must not be more than 25 pounds and should be able to be handled by one man. The effective projected area (EPA) must not exceed 0.5 square feet.

(b) Housing. The housing shall be a precision aluminum die-casting composed of aluminum meeting ASTM Specification A380. It must be substantial and adequate enough to withstand the strains likely to be imposed on the housing when installed and in service. The housing must enclose the slipfitter, LED arrays, photocontrol receptacle, terminal board, surge protector, and the electronic driver, with provision for proper mounting of these parts. The housing must have provision on its top surface to permit leveling with a spirit level. The housing must have integral heat sink characteristics, such that all enclosed components will operate within their designed operating temperatures under expected service conditions. No extra items shall be installed as heat shields or heat sinks. All heat shields and heat sinks shall be integral to the luminaire. The housing will have an appearance similar to existing cobra-head housings typically in use on Chicago's alleys.

The housing shall be designed to allow water shedding. The housing shall be

designed to minimize dirt and bug accumulation on the optic surface.

(c) Slip Fitter. The slip fitter shall be suitable for attachment over the end of a two (2) inch steel pipe with an approved means of clamping it firmly in place, and must provide a cast-in pipe-stop. The slip fitter must be designed to permit adjustment of not less than five (5) degrees above and below the axis of the mounting bracket. The slip fitter must contain an approved shield around the pipe entrance to block entry of birds.

(d) Driver Door-Panel. The driver components must be completely assembled and mounted on a die-cast aluminum door-panel composed of aluminum alloy A380. The door-panel must be hinged to the luminaire housing, suitably latched and fastened at the closing end. It must be made to be removed easily. The hinge and fastening devices must be captive parts which will not become disengaged from the door panel.

(e) Refractor. The refractor must be flat, crystal clear, heat-resistant, boro-silicate glass, well annealed, homogeneous, and free from imperfections and striations. As an option, a clear drop lens refractor of acrylic should be available to replace the flat glass refractor.

(f) Refractor Holder. The refractor holder must be hinged to the luminaire housing and must open approximately 90 degrees. The refractor must be securely held in the refractor holder. The refractor holder must permit simple removal and replacement of the refractor without the use of tools. The hinge must prevent the refractor holder from disengaging and dropping in case it should swing open.

(g) Latch. An approved latch must be provided for latching the refractor holder to the housing. The latch must be located opposite a suitable hinge. The latch must be a firm-gripping, easy opening, single action, positive latching type requiring no tools.

(h) Gaskets. Wherever necessary, in order to make a completely dustproof assembly, gaskets of silicone rubber or other specifically approved material must be provided.

(i) Hardware. All machine screws, locknuts, pins and set screws necessary to make a firm assembly, and for its secure attachment to the mast arm, must be furnished in place. All hardware must be of stainless steel, copper silicon alloy or other non-corrosive metal, and where necessary must be suitably plated to prevent electrolytic action by contact with aluminum.

(j) Finish. The luminaire shall have a polyester powder coat with a minimum 2.0 mil thickness. Surface texture and paint quality will be subject to

approval. Color must be gray (designated ANSI No. 70). A paint chip must be submitted as a sample upon request. The finish shall pass 1000 hours of salt spray per ASTM B117.

(k) Ingress Protection. The luminaire housing shall have an ingress protection rating of IP54 or better as described in IEC standard 60529 (also ANSI C136.25). The optical system shall have an IP66 rating.

(l) The luminaire shall be UL listed. It shall be suitable for wet locations per UL 1598.

(m) The luminaire shall be rated to operate between -40° to +50° Centigrade.

(n) The luminaire shall have the option of adding a house side shield.

(o) A bar code with pertinent information for warranty and maintenance shall be attached to the inside of the housing. A separate bar code label shall be on the inside of the driver door.

(p) On the underside of the housing there should be a decal indicating the total wattage and the street application for the luminaire (i.e. "54W,LED, AL" for 54 watt LED luminaire for alleys). The decal should have black characters on a white background. The decal must be legible from ground level.

ELECTRICAL COMPONENTS

4. (a) LED Optical Array. The LED arrays shall be optimized for the required roadway photometrics. The arrays must be properly secured at the factory and must not require field adjustment for optimum photometric performance. The LEDs shall deliver a minimum of 70% of initial lumen output at 100,000 hours (L70 at 100K). LEDs shall provide a color rendition index (CRI) of 70. The color temperature of the LEDs shall be 4000˚ Kelvin. The optical unit shall have an IP66 rating.

(b) Terminal Board-Fuse Block. A terminal block of high grade molded plastic of the barrier or safety type must be mounted within the housing in a readily accessible location. It must provide all terminals needed to completely prewire all luminaire components. The terminal block must either incorporate a barrier isolated section with fuse clips to take a "small-dimension" cartridge fuse, or a separate barrier protected fuse block must be provided. It must be UL and CSA certified.

The fuses shall be rated at 10 amps 600 VAC with a 100,000 AMPS interrupting capacity. Fuses shall be Buss type KTK, or equal. The fuse block must be wired to the appropriate terminals. The terminal board-fuse

block must have plated copper or plated brass, clamp-type pressure terminals of an approved type for "line" connections, to accommodate wire sizes from #12 to #8 A.W.G. The terminals for connection of internal components must be either the screw-clamp or quick disconnect type.

(c) Driver Requirements:

1. Voltage. The electronic driver shall operate at a nominal input voltage range of between 120 and 277 volts, 60 Hertz.

2. The driver shall provide the proper operating voltage to the LED arrays. Output frequency must be equal to or greater than 120 Hertz to avoid flicker.

3. Power Factor. The power factor of the driver over the design range of input voltages specified above must not be less than 90%.

4. The driver input current must have Total Harmonic Distortion (THD) of less than 20% when operated at nominal line voltage.

5. The driver must be thermally protected to shut off when operating temperatures reach unacceptable levels.

6. The driver shall be short circuit protected and overload protected.

7. The driver must meet the EMI (electromagnetic interference) requirements of the FCC rules and regulations, Title 47 CFR, Part 15.

8. The driver shall have a Class A sound rating per ANSI C63.4.

9. Transient voltage complies with ANSI C62.41 Category A.

10. The current should be as recommended by the LED manufacturer. The current level should be such that the LEDs are not overdriven or underdriven. LED current should produce the most efficient light output without compromising the life of the LEDs.

(d) Surge Protection. Surge protection shall be 10kV/10kA per ANSI C62.41.2. The surge protection device shall be a 3 wire device. The suppressor shall be NRTL listed and be in accordance with UL 1449.

(e) The minimum luminaire efficacy shall be 90 lumens per watt (based on initial lumen output).

(f) Mounting. The driver shall be mounted and fastened on the driver door in a manner such that the driver will remain secure and capable of withstanding the vibrations and shocks likely to occur when installed and in service. The driver must be readily removable for replacement.

(g) Wiring. All components must be completely factory wired with non-fading, color coded leads. These leads must be insulated with an approved class of insulation and must be #16 AWG conductor minimum. All wires within a single circuit path must be of the same size. No wire nuts will be allowed. No unnecessary splices will be allowed. The use of wiring smaller than #16 AWG will require the written approval of the Commissioner. Color coding will be in a manner approved by the Commissioner. A complete wiring diagram must be displayed at an approved location on the interior of the luminaire and must include all luminaire and component identification and ratings. The wiring diagram must be provided on high quality material that will be resistant to cracking, yellowing, and fading in a luminaire environment. Quick disconnects must be provided for all components.

(h) Photo-control Receptacle. A twist-lock receptacle for a photo-control that meets ANSI Standard C136.41 for dimming receptacles must be mounted in the top of the housing with provision for proper positioning of the photo-control. The receptacle shall be 7 position unit having 3 power prongs and 4 contacts. Two contacts shall be for 0-10 volt DC dimming. The other 2 contacts will be for a digital addressable lighting interface. All wire leads from the receptacle must be properly terminated. The receptacle must be able to be repositioned without the use of tools. A photo-control is not required to be furnished, nor is a shorting cap to be provided.

(i) Component Mounting.

1. Modular Construction. All electrical components must be securely mounted in such manner that individual components can be easily maintained or replaced. Permanent straps or tie-wraps will not be permitted. The entire assembly should be easily disconnected and removed for replacement.

2. Interchangeability. Components must be mutually field interchangeable so that units can be restored to working condition without trouble shooting components.

PHOTOMETRIC REQUIREMENTS

5. (a) The manufacturer must demonstrate that the luminaires will meet or exceed the specified photometric requirements. The manufacturer must provide photometric calculations using published luminaire data as part of the

submitted package. The proposal must contain luminaire photometric performance with results equal to or better than those listed in this specification. Submittal information must include computer calculations based on the controlling given conditions which demonstrate achievement of all listed performance requirements. The submitted roadway lighting calculations must be done in accordance with I.E.S. RP-8-14, and must include point-by-point illuminance, luminance and veiling luminance as well as listings of all indicated averages and ratios.

(b) Unless otherwise indicated, the light distribution will be classified as medium-cutoff-Type I/II (M-C-I/II), as defined in Appendix E of I.E.S. RP-8-14.

(c) Performance Requirements (0.7 light loss factor):

1. Roadway Illuminance:

Average Horizontal	1.0 fc
Uniformity Ratio Av/Min	6:1

2. Roadway Luminance:

Average Luminance	0.7 cd/m2
Uniformity Ratio Av/Min	6:1
Uniformity Ratio Max/Min	10:1
Max Veiling Luminance	0.5

(d) The photometrics shall be run for the specific requirements. If the luminaires are to be obtained for no specific project, the luminaires must meet the performance requirements for the following physical conditions:

Right-of-way	16’
Mounting height	18’
Setback	0’
Arm length	2’
Spacing (one side)	150’
Pavement	R3

TESTING

6. (a) Testing. All testing must be done on a prototype of the actual luminaire to be provided under this specification. If recent test results are available, they may be considered as meeting the testing requirements of this specification. The Commissioner or Commissioner’s representative will have the final approval of which tests are adequate.

(b) The manufacturer will be responsible for all costs associated with the specified testing, incidental to this contract.

(c) Photometric testing must be in accordance with IES recommendations. The tests, at a minimum, must yield:

1. An isofootcandle chart with maximum candela and half maximum candela trace.
2. An isocandela diagram.
3. Maximum plane and maximum cone plots of candela.
4. A candlepower table (house and street side).
5. A coefficient of utilization chart.
6. A luminous flux distribution table.

(d) The luminaire must meet the electrical and photometric requirements of IESNA LM -79.

(e) The luminaire must meet the lumen maintenance requirements of IESNA LM -80.

(f) The luminaire must meet the requirements of IESNA TM -21 for long term maintenance of LED light sources.

(g) The LEDs must meet the requirements for chromaticity per ANSI C78.377.

(h) The following applicable UL standards shall be met:

1. 8750 LED Light Sources in Lighting Products
2. 1598 Luminaires
3. 1012 power units other than Class 2
4. 1310 Class 2 power units
5. 2108 low voltage lighting systems

(i) Additional Types of Testing.

1. Interchangeability of all component parts.

2. Thermal testing in accordance with U.L. Standard 1572 or Standard 1598. The fixture must be placed in a controlled 25° Celsius environment and be energized for a minimum of 8 hours. At no time will any of the components exceed the manufacturer's recommended

operating temperatures. At no time will any surface of the refractor exceed the manufacturer's recommended temperature limits.

3. Vibration testing in accordance with ANSI Standard C136.31. Upon completion of the test, all set screws, castings, and components must be secure and undamaged. The luminaire will not be energized for this test. However, the luminaire must be fully operational after the test.

4. Moisture testing in accordance with U.L. Standard 1572 or Standard 1598. The luminaire will be subjected to a water spray from various directions for a sufficient amount of time. After the water spray the inside of the refractor must remain dry and the fixture should be demonstrated to operate properly.

PACKAGING

7. (a) Packing. Each luminaire assembly must be packed in a suitable carton so secure that it must not be damaged in shipment and handling.

(b) Marking. Each carton containing a luminaire must be clearly marked on the outside in letters not less than three-eighths (3/8) inch tall with the legend: "LUMINAIRE, LED, ALLEY, IES CUTOFF TYPE I/II", the appropriate City Commodity Code Number, the name of the manufacturer, the date of manufacture, and the contract number under which the luminaire is furnished.

ELECTRICAL SPECIFICATION No. 1600
CITY OF CHICAGO
DEPARTMENT OF
TRANSPORTATION
DIVISION OF
ENGINEERING
DECEMBER 9, 2016

OUTDOOR LED LUMINAIRE SPECIFICATIONS:
RESIDENTIAL STREETS, ALLEYS, & ARTERIAL STREETS (Cobra Head)

I. SUBJECT

A. This specification states the requirements for non-ornamental Light Emitting Diode (LED) outdoor lighting luminaires. The specified LED luminaires will be used to replace existing High Pressure Sodium (HPS) and Ceramic Metal Halide (CMH) luminaires on Chicago residential streets, arterial streets, and alleys. The LED luminaires will be integrated into a centralized lighting management system.

II. GENERAL

A. References

American National Standards Institute (ANSI)

- ANSI C78.377-2015, "American National Standard for Electric Lamps— Specifications for the Chromaticity of Solid State Lighting (SSL) Products"
- ANSI C82.77-10-2014, "American National Standard for Lighting Equipment—Harmonic Emission Limits—Related Power Quality Requirements"
- ANSI C136.2-2015, "American National Standard for Roadway and Area Lighting Equipment—Dielectric Withstand and Electrical Transient Immunity Requirements"
- ANSI C136.10-2010, "American National Standard for Roadway and Area Lighting Equipment—Locking-Type Control Devices and Mating Receptacles—Physical and Electrical Interchangeability and Testing"
- ANSI C136.15-2015, "American National Standard for Roadwa and Area Lighting Equipment—Luminaire Field Identification"
- ANSI C136.22-2004 (R2009, R2014), "American National Standard for Roadway and Area Lighting Equipment—Internal Labeling of Luminaires"
- ANSI C136.25-2013, "American National Standard for Roadway and Area Lighting Equipment—Ingress Protection (Resistance to Dust, Solid

Objects and Moisture) for Luminaire Enclosures”

- ANSI C136.31-2015, “American National Standard for Roadway and Area Lighting Equipment—Pole Vibration”
- ANSI C136.37-2011, “American National Standard for Solid State Light

Sources Used in Roadway and Area Lighting”

- ANSI C136.41-2013, “American National Standard for Roadway and Area Lighting Equipment–Dimming Control Between an External Locking Type Control and Ballast or Driver”
- ASTM B85/B85M-14, “Standard Specification for Aluminum-Alloy Die Castings”
- ASTM B117-16, “Standard Practice for Operating Salt Spray (Fog) Apparatus”
- ASTM D523-14, “Standard Test Method for Specular Gloss”
- ASTM D1654-08, “Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments”
- ASTM G154-12a, “Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials”

Illuminating Engineering Society of North America (IES)

- ANSI/IES LM-63-02, “Standard File Format for Electronic Transfer of Photometric Data”
- IES LM-79-08, “Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products”
- ANSI/IES LM-80-15, “IES Approved Method: Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules”
- ANSI/IES RP-8-14, “Roadway Lighting”
- IES TM-21-11 (with Addendum B), “Projecting Long Term Lumen Maintenance of LED Light Sources”

Institute of Electrical and Electronics Engineers (IEEE)

- IEEE Std 1789-2015, “IEEE Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers”

International Electrotechnical Commission (IEC)

- IEC 60929:2011 (with Amendment 1), “AC and/or DC-supplied electronic control gear for tubular fluorescent lamps - Performance requirements”

Underwriters Laboratories (UL)

- ANSI/UL 1598 (3rd Edition), "Luminaires”

B. Submittal Requirements:

The Contractor must submit the following information pertaining to each specified luminaire type within fifteen (15) days of request:

1. Completed ATTACHMENT G – Submittal Form

2. Product Data Sheets.

a) Luminaire data sheets – including summary product description, dimensioned outline drawings, and nominal characteristics including but not limited to: initial luminous flux (lumens), input power (watts), input voltage range (volts), LED drive current (milliamps), correlated color temperature (kelvins), color rendering index, effective projected area (square feet) and weight (pounds).

b) LED Driver data sheet – including information described in LED Driver Requirements Section III-I-3.

c) LED light source data sheet

d) Surge protection device data sheet - if applicable

3. Photometric Performance Data

The manufacturer must provide photometric calculations, as part of each luminaire's submittal package, that demonstrate the luminaire's photometric performance will meet or exceed the photometric requirements listed in this specification. The submitted lighting calculations must include point-by-point illuminance, luminance and veiling luminance data, as well as listings of all indicated averages and ratios. Photometric reports must include the following information and be in accordance with the standards listed below:

a) IES LM-79-08 photometric report that includes measured values for initial luminous flux, input power, correlated color temperature, and color rendering index.

b) ANSI/IES LM-63-02 electronic format photometric file that corresponds to the LM-79 report.

c) LM-63 photometric calculations that demonstrate compliance with the illumination requirements specified herein using the LM-63 file. Calculation grids and observer locations not specified herein must be in accordance with ANSI/IES RP-8-14.

d) IES TM-21-11 calculations that derive the lumen maintenance

(lamp lumen depreciation or LLD) factor applied to photometric calculations specified herein.

- ☐ ANSI/IES LM-80-15 and in-situ temperature measurement testing (ISTMT) reports containing data used in TM-21 calculations must also be submitted.

- TM-21 calculations must apply to the maximum LED case temperature from ISTMT, shall not extrapolate beyond six times the duration of available LM-80 test data, and must be submitted in the spreadsheet format of the ENERGY STAR TM-21 calculator (https://www.energystar.gov/products/spec/luminaires_specification_version_2_0_pd).

LM-79, ISTMT, and LM-80 reports must correspond directly to submitted luminaires, and must be produced by test laboratories that satisfy the Testing Laboratory Requirements of the DesignLights Consortium (www.designlights.org/content/QPL/ProductSubmit/LabTesting).

ISTMT must be conducted in accordance with the DesignLights Consortium Manufacturer's Guide (https://www.designlights.org/content/qpl/productsubmit).

ISTMT shall be conducted in an ambient temperature of 25 ± 5 °C. Ambient temperature variations above or below 25 °C shall be respectively subtracted from or added to temperatures recorded at points on the luminaire.

4. Safety Certification - file number indicating compliance with UL 1598. Applicable testing bodies are determined by the US Occupational Safety Health Administration (OSHA) as Nationally Recognized Testing Laboratories (NRTL) and include: CSA (Canadian Standards Association), ETL (Edison Testing Laboratory), and UL (Underwriters Laboratory).

5. Vibration Testing - the luminaire must comply with ANSI C136.31 at Vibration Test Level 2 (3.0 G).

6. Product Samples - at least two samples of each luminaire that the contractor proposes to use must be submitted to the City. All samples must be representative production units and be supplied at no cost to the City.

C. Assembly.
Each luminaire must be delivered completely assembled, wired, and ready for installation.

D. Warranty.
The luminaire manufacturer must warrant the performance and construction of luminaires to meet the requirements of this specification, and must warrant all parts, components and appurtenances against defects due to design, workmanship or material developing within a period of ten (10) years from the date of acceptance by the City.

- The inability of a luminaire to be dimmed will constitute a luminaire

failure.

- Failure of 10% or more of the LED light sources (packages or arrays/modules) in a luminaire will constitute a luminaire failure.

- The warranty must apply for application on all of the City's existing electrical systems, both grounded and ungrounded.
- During the warranty period the City may, from time to time, test a random sampling of 10-20 luminaires for verification of light output per IES LM-79 and to test dimming functionality for a given luminaire population. The percentage of luminaires not performing as required in the random sampling will be applied to the total population quantity to determine the number of new luminaire replacements that must be delivered to the City by the manufacturer, without expense to the City.

E. Manufacturing Experience and Capacity

The manufacturer must demonstrate at least a five year history of manufacturing LED roadway and outside area luminaires by providing a list of prior projects with project description, date, location, quantities and reference contact information. The manufacturer must also demonstrate the capacity to supply the quantities required for the contract in a timely manner.

III. CONSTRUCTION

A. Weight

The net weight of these luminaires must not be more than 30 pounds.

B. Housing.

The preferred luminaire housing material is die-cast aluminum alloy meeting ASTM Specification A380. Alternate materials may be considered. The housing must enclose the mounting hardware, LED arrays, control receptacle, terminal board, and electronic driver. The housing must include a surface to facilitate leveling with a spirit level. The housing must have integral heat sink characteristics, such that all enclosed components will operate within their designed operating temperatures under expected service conditions. No external or removable heat shields or heat sinks; are permitted. The housing must be designed to encourage water shedding. The housing must be designed to minimize dirt and bug accumulation on the optic surface.

C. Mounting Provisions.

The luminaire must include a heavy gauge slip fitter clamping assembly suitable for secure attachment over the end of a two (2) inch 2" IP (2.375" OD) steel pipe with an approved means of clamping it firmly in mounting bracket. The slip fitter mounting clamp must contain an approved shield around the pipe entrance to block the entry of birds.

D. Access Door-Panel.

An access door panel allowing access to the terminal strip and LED driver must be provided. A die-cast aluminum door-panel composed of aluminum alloy A380
is preferred; alternate materials may be considered. The door-panel must be hinged to the luminaire housing and suitably latched and fastened at the closing end. It must be made to be removed easily. The hinge and fastening devices must be captive parts which will not become disengaged from the door panel.

E. Hardware.

All machine screws, locknuts, pins and set screws necessary to make a firm assembly, and for its secure attachment to the mast arm, must be furnished in place. All hardware must be of stainless steel, zinc plated steel, copper silicon alloy or other non-corrosive metal, and where necessary must be suitably plated to prevent electrolytic action by contact with dissimilar metals.

F. Finish.

The luminaire must have a polyester powder coat with a minimum 2.0 mil thickness. Surface texture and paint quality will be subject to approval. Color must be as specified in the order. A paint chip must be submitted as a sample upon request. The finish must exceed a rating of six per ASTM D1654 after 1000 hours of testing per ASTM B117. The coating must exhibit no greater than 30% reduction of gloss per ASTM D523 after 500 hours of QUV testing at ASTM G154 Cycle 6.

G. Ingress Protection.

1. The luminaire electric compartment housing must have an ingress protection rating of IP54 or better as described in ANSI C136.25-2013). The optical system must have a minimum rating of IP 66.

2. The luminaire must be listed for wet locations by a U.S. Occupational Safety Health Administration (OSHA) Nationally Recognized Laboratory (NRTL) and have a safety certification and file number indicating compliance with UL 1598.

H. General Luminaire Requirements

1. The luminaire must be rated to operate between -40° to +50° Celsius.

2. The luminaire must have the option of adding a house side shield. The shield should be designed to be easily installed in the field. The house side shield must be composed of a sturdy material capable of withstanding vibrations and weather conditions. The shield must cut off light trespass at approximately one mounting height behind the pole.

3. The luminaire must meet the requirements of ANSI C136.22 for internal labeling. A bar code with pertinent information for warranty and maintenance must be attached to the inside of the housing. A separate bar code label must be on the driver

4. The luminaire must be able to provide pertinent product information, for warranty and maintenance purposes, in a digital format that is compliant with the Digital Addressable Lighting Interface (DALI) protocol. This information will be transmitted through the networked Lighting Management control system.

I. Electrical Components

1. LED Optical Arrays
   a) The LED arrays must be properly secured at the factory and must not require field adjustment for optimum photometric performance.

2. Terminal Block
   a) A terminal block of high grade molded plastic of the barrier or

safety type must be mounted within the housing in a readily accessible location.

b) Terminal block wiring; all necessary terminals, pre-wired to all luminaire components, must be provided.

c) Terminal block terminals must have copper plated or brass plated, clamp-type pressure connectors of an approved type for "line" connections, to accommodate wire sizes from #12 to #8 A.W.G.

d) Terminal block terminals for internal component connections must

be either the screw-clamp or quick disconnect type.

3. LED Driver:

a) Voltage. The electronic driver must operate at an input voltage range of between 120 and 277 volts, 60 Hertz. It must automatically sense the input voltage and adjust the output accordingly. The City uses nominal input voltages of 120, 208, and 240 for street lighting. When operated at any supply voltage between 80 percent and 110 percent of its rated supply voltage and at rated input frequency, a driver shall provide current and/or voltage regulation that equals or exceeds the values specified by the manufacturer.

b) Electrical Safety. Luminaires must operate at or below the Low-Risk Level, as defined in Figure 18 of IEEE 1789-2015. This requirement must be satisfied across the dimming range.

c) Power Factor (PF). The power factor of the driver over the design range of input voltages specified above must be in accordance to ANSI C82.77-2014. PF must be $\geq$ 0.9.

d) Total Harmonic Distortion (THD). The driver input current must have specified THD in accordance to ANSI C82.77-2014. THD must be $\leq$32%.

e) Thermal Protection. The driver must be thermally protected to shut off when operating temperatures reach unacceptable levels.

f) Electromagnetic Interference. Luminaire must comply with the FCC radiation emission limits for Class B digital devices given at 47 CFR 15.109.

g) Electrical Transient Immunity.

- Dielectric Withstand Testing - luminaire must meet the performance requirements specified in ANSI C136.2-2015 for dielectric withstand, using the DC test level and configuration.

- Electrical Transient Immunity - luminaire must meet the performance requirements specified in ANSI C136.2-2015 for electrical transient immunity, using the Enhanced (10 kV / 5 kA) combination wave test level.

- Transient Immunity Testing Requirements
  - During electrical transient immunity testing, the device under test (DUT) must: be connected to the power source through a series coupler/decoupler network (CDN), using a two-wire (hot or hot/neutral) connection between both the

power supply and CDN input and the CDN output and DUT.

- If AC mains is used to power the DUT, the input waveform must be characterized and documented both before and after electrical transient immunity testing, with the DUT operating at rated full output.

- For Pre-Test DUT Characterization, the diagnostic measurements shall, at a minimum, include the following: real power, input current (RMS; Root-Means-Square), power factor, and current distortion factor (THD-I Total Harmonic Distortion) when operating at rated full output.

- Manufacturer must indicate on submittal form whether failure of the electrical transient immunity system can possibly result in disconnect of power to luminaire.

h) Dimming Capability. The driver must be capable of dimming. The dimming range must be 10% to 100% of full output. The digital lighting interface used for dimming must be DALI (Digital Addressable Lighting Interface) as per the requirements of IEC 62386. There must be a minimum of 100 dimming steps between the top and bottom of the dimming range.

4. Wiring.

a) All components must be completely factory wired with non-fading, color coded leads. These leads must be insulated with an approved class of insulation and must be #16 AWG conductor at a minimum.

b) All wires within a single circuit path must be of the same size.

c) No wire-nut splicing will be allowed.

d) No unnecessary splices will be allowed.

e) Quick disconnects must be provided for all components.

f) All wires must be properly terminated.

5. Control Device Receptacle and Cap.

a) Twist-lock Receptacle for a control device that meets ANSI C136.41 must be mounted in the top of the housing with provision for proper positioning of the control device.

b) 7-pin Receptacle. The luminaire control receptacle must be fully

prewired and compliant with ANSI C136.41.

c) 3-prong Shorting Cap that meets ANSI C136.10 must be provided.

d) Receptacle Wire Leads must all be properly terminated.

e) Receptacle repositioning. The receptacle must be able to be repositioned without the use of tools.

f) Control Devices Not Included in LED Specifications. Whereas specifications for control receptacles are included, specifications for control devices are not. The control device performance requirements are part of the lighting management system specifications in the Smart Lighting Project Technology specifications.

6. Component Mounting.
All electrical components must be securely mounted in such manner that individual components can be easily maintained or replaced. Permanent straps or tie-wraps will not be permitted. The entire assembly should be easily disconnected and removed for replacement.

IV. PHOTOMETRIC REQUIREMENTS

1. Light Pollution.
To limit light pollution, the submitted luminaires must not emit any light above the horizon (0 lumens at angles $\geq$ 90° from luminaire nadir).

2. Lumen Maintenance.
a) LED arrays must deliver a minimum of 90% of initial lumen output at 36,000 hours of operation.

b) Light Loss Factor (LLF) < 1.0. Calculations for maintained values,
i.e. LLF = LLD x LDD x LAT.

(1) Lamp Lumen Depreciation (LLD) calculated at 60,000 hours as per Section II-B-3-d above,
(2) Luminaire Dirt Depreciation (LDD) $\leq$0.90, and
(3) Luminaire Ambient Temperature (LAT) $\leq$0.96

Luminaires with less than 10,000 hours of available LM-80 test data may be submitted for consideration but must be clearly indicated as such.

3. Color Attributes

a) Color Rendering Index (CRI) shall be no less than 65.

b) Nominal Correlated Color Temperature (CCT) shall be 3000K as defined by ANSI C78.377 and described below:

Manufacturer-Rated	Allowable IES LM-79 Chromaticity Values

Nominal CCT (K)	Measured CCT (K)	Measured Duv
3000	2870 to 3220	-0.006 to 0.006

4. City of Chicago Typical Lighting Contexts

ATTACHMENT A (below) lists the photometric performance requirements for luminaires used in the following typical municipal outdoor lighting applications:

- Alleys.
- Modern Residential Streets - staggered poles on both sides.
- Legacy Residential Streets - one-sided pole spacing.
- Legacy Residential Intersections and Alley Entrances.
- Arterial Streets – two-sided opposite pole spacing
- Arterial Streets – two-sided staggered pole spacing
- Arterial Streets – one-side pole spacing

See ATTACHMENTS B, C, & C-1 for residential street layouts.

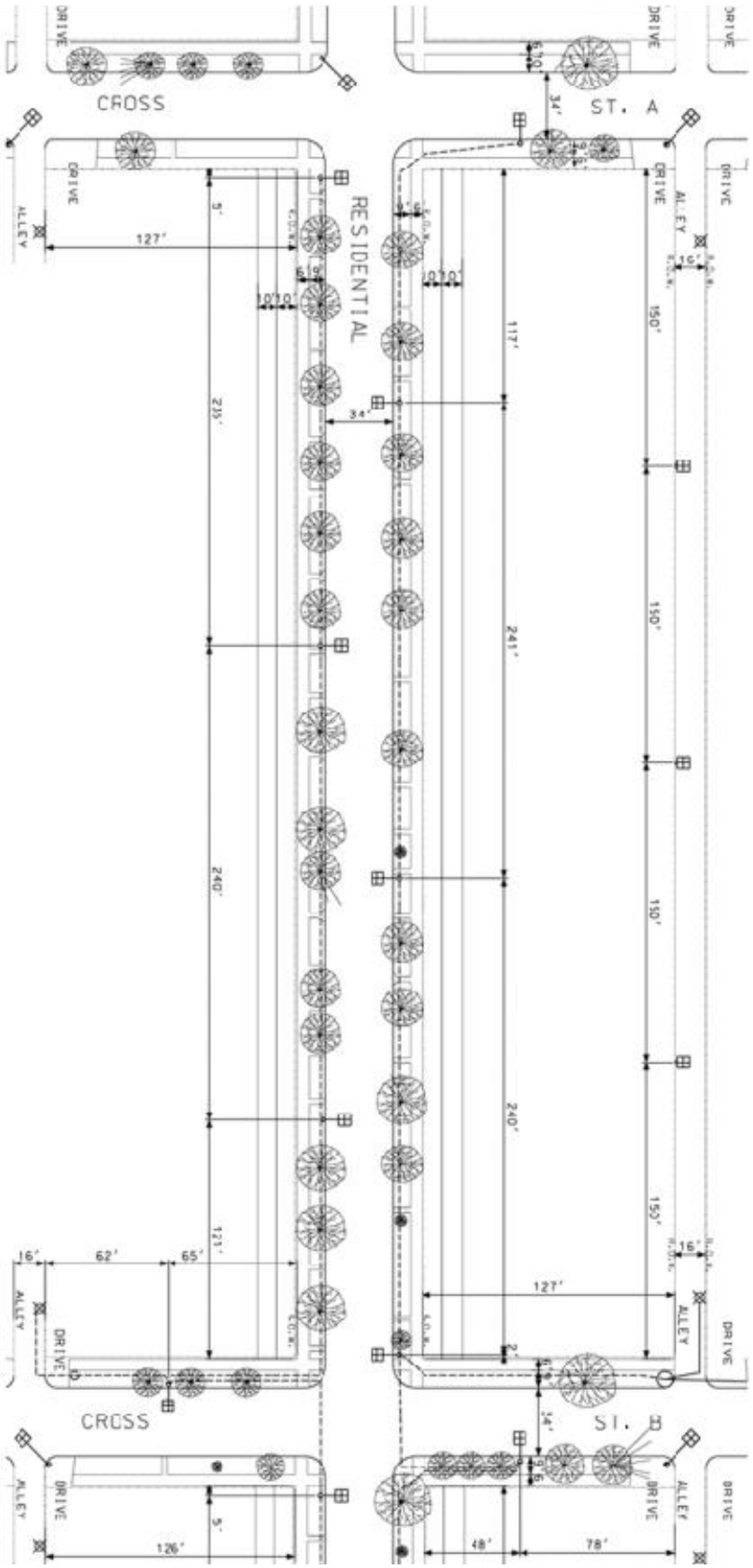
Note: The layout for (i) the intersection of two Legacy Residential Streets, (ii) an alley entrance intersecting with a Legacy Residential Street, and (iii) a typical alley layout is found in ATTACHMENT C-1. Luminaires for both alley entrance lighting and intersection lighting are oriented 45° from the curb line. All other luminaires are oriented 90° from (i.e., perpendicular to) the curb line.

See ATTACHMENTS D, E, & F for arterial layouts.

ATTACHMENT A – Photometric Performance Requirements

STREET PARAMETERS							
TYPICAL LIGHTING CONTEXT	**RESIDENTIAL***		**ALLEY**		**ARTERIAL**		
POLE CONFIGURATION*	STAGGERED	ONE-SIDED	INT R-R and R-A	ONE-SIDED	OPPOSITE	STAGGERED	ONE-SIDED
RIGHT OF WAY (Width)	66 ft.	66 ft.	66 ft.	16 ft.	100 ft.	80 ft.	66 ft.
IES PAVEMENT CLASS	R3	R3	R3	R3	R3	R3	R3
STREET WIDTH (Curb to Curb)	34 ft.	34 ft.	34 ft.	16 ft.	80 ft.	60 ft.	48 ft.
LANES (Incl Prking &Median)	4	4	4	2	7	6	4
PARKWAY (Width)	10 ft.	10 ft.	10 ft.	N/A	4 ft.	4’	N/A
SIDEWALK (Width)	6 ft.	6 ft.	6 ft.	N/A	6 ft.	6 ft.	9 ft.
HEIGHT TO LUMINAIRE	18 ft.	22 ft.	22 ft.	18 ft.	33 ft.	33 ft.	33 ft.
MAST ARM LENGTH	8 ft.	15 ft.	15 ft.	1 ft.	12 ft.	12 ft.	8 ft.
POLE SETBACK (From Curb to Center of Pole)	3 ft.	2 ft.	2 ft.	N/A	3 ft.	3 ft.	3 ft.
IN-LINE POLE SPACING	See Site Plan Attachments B thru F for pole spacing assumptions for each Pole Configuration context						
MAINTAINED PERFORMANCE REQUIREMENTS							
LUMINAIRE REQUIREMENTS	STAGGERED	ONE-SIDED	INT R-R and R-A	ONE-SIDED	OPPOSITE	STAGGERED	ONE-SIDED
Max Input Power - Default /Normal Luminance (Watts)	120	130	130	80	180	180	180
Default/Normal AVG. Luminance (cd/m²)	≥1.5	≥1.5	≥1.5	≥.95	≥1.7	≥1.7	≥1.7
AVG/MIN Uniformity Ratio	≤ 6:1	≤ 6:1	≤ 6:1	≤ 6:1	≤ 3:1	≤ 3:1	≤ 3:1
MAX/MIN Uniformity Ratio	≤10:1	≤10:1	≤10:1	≤ 10:1	≤ 5:1	≤ 5:1	≤ 5:1
MAX Veiling Luminance Ratio	≤ 0.4	≤ 0.4	≤ 0.4	≤ 0.4	≤ 0.3	≤ 0.3	≤ 0.3
AVG. Boosted Luminance (cd/m²) [Add-Alternate]	≥2.25	≥2.25	≥2.25	≥1.5	≥2.5	≥2.5	≥2.5
SIDEWALK							
Default AVG. Horizontal Illuminance (fc)	≥0.50	≥0.50	≥0.50	N/A	≥0.50	≥0.50	≥0.50
AVG.MIN Uniformity Ratio (Horizontal Illuminance)	≤ 4:1	≤ 4:1	≤ 4:1	N/A	≤ 4:1	≤ 4:1	≤ 4:1
LIGHT TRESPASS RESTRICTIONS - (as measured in a vertical plane 10' beyond ROW ≤3' height)							
MAX Vertical Illuminance	≤ 0.07	≤ 0.30	≤0.30	≤ 0.05	≤ 0.3	≤ 0.30	≤ 0.30

*Residential Pole Configuration Contexts: See Attachments B, C, & C-1
Staggered = Residential street with Modern poles; (aluminum davit poles staggered on both sides of street) Attachment B.
One-Sided = Residential street with Legacy poles; (steel poles on one side of street) Attachment C
INT R-R = intersection of two Legacy residential streets, illuminated by one luminaire oriented diagonally (45°), Attachment C-1.
INT R-A = intersection of Legacy residential street with alley, illuminated by one luminaire oriented diagonally (45°), Attachment C-1.


CROSS
ST. A
RESIDENTIAL
CROSS
ST. B
DRIVE
ALLEY
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117'
150'
241'
240'
235'
34'
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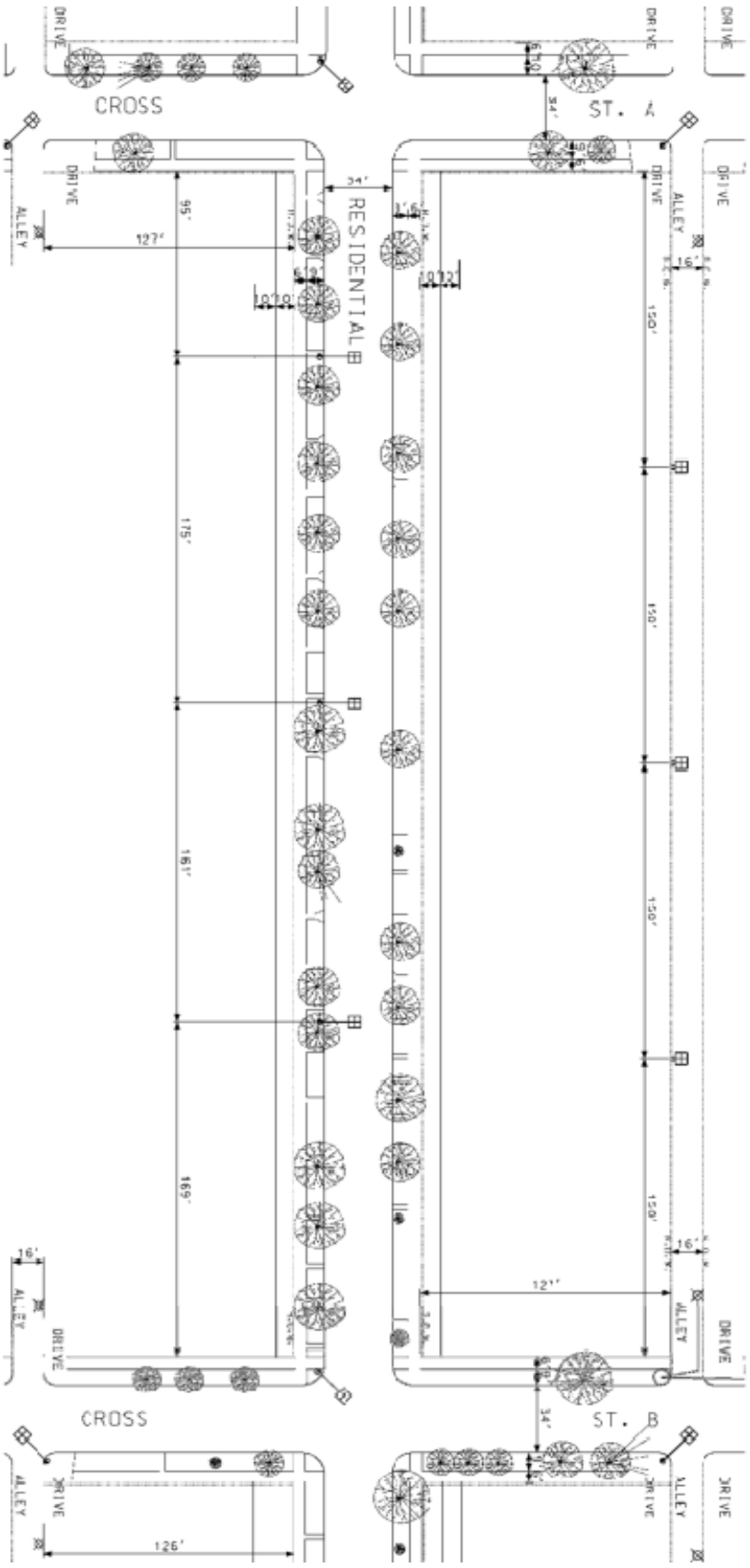
16'
62'
65'
126'
48'
78'


CROSS
ST. A
RESIDENTIAL
CROSS
ST. B
DRIVE
ALLEY
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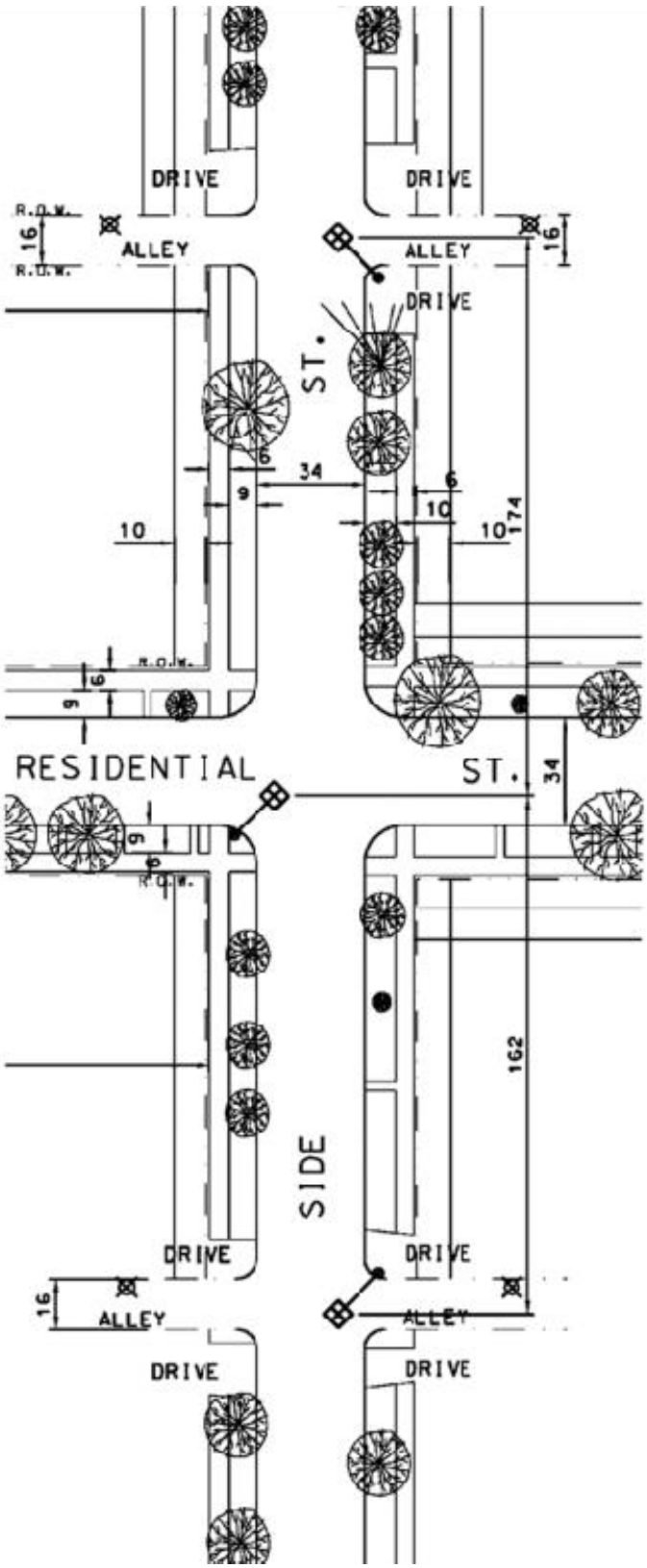
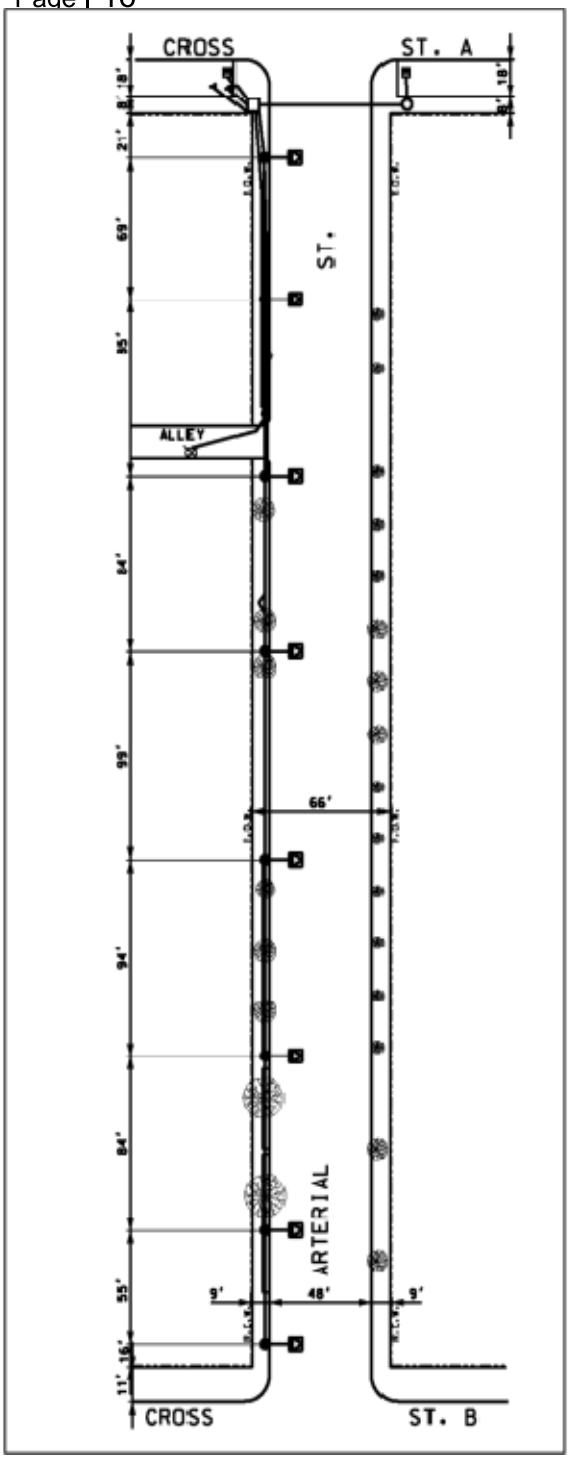
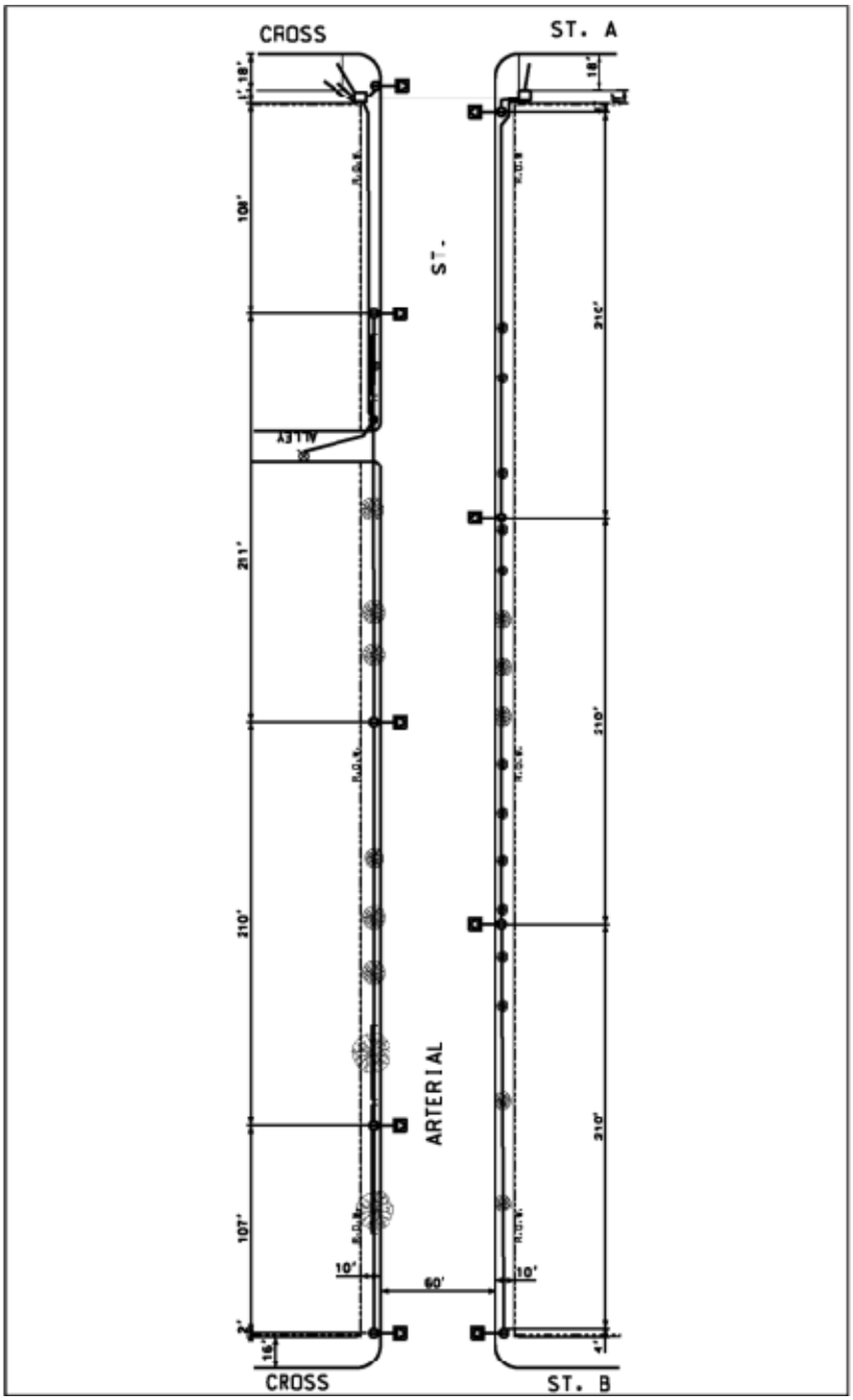
95'
115'
161'
169'
150'
121'
126'

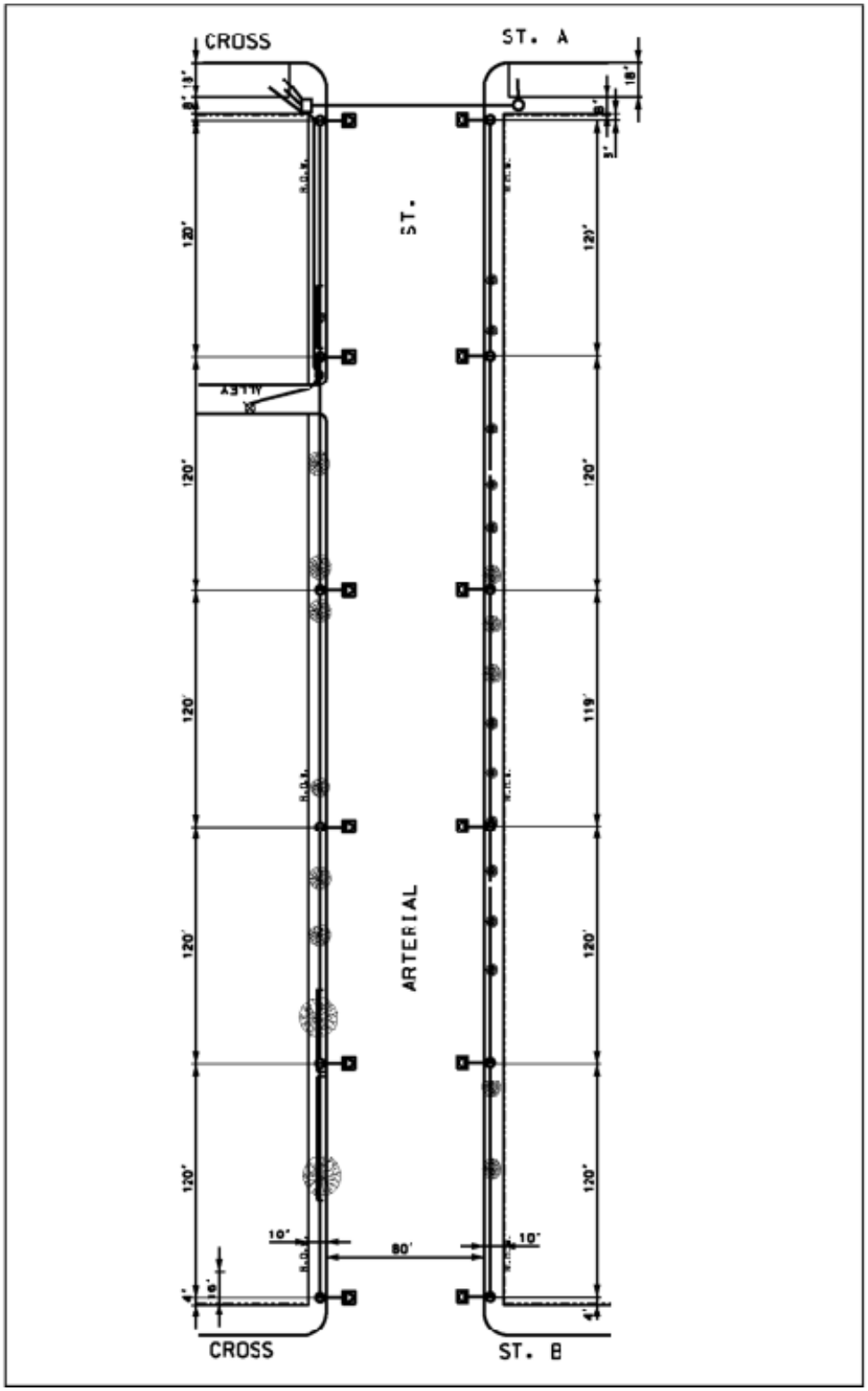

DRIVE
DRIVE
R.O.W.
16
R.O.W.
ALLEY
ALLEY
16
DRIVE
ST.
34
6
9
10
10
10
174
R.O.W.
6
9
RESIDENTIAL
ST.
34
9
6
R.O.W.
162
SIDE
DRIVE
DRIVE
16
ALLEY
ALLEY
DRIVE
DRIVE

ATTACHMENT D – Arterial Street Single-Sided Poles





ATTACHMENT E – Arterial Street - Staggered Poles



ATTACHMENT F - Arterial Street Opposite Poles

ATTACHMENT G - Product Submittal Form

Lighting Context	e.g. Alleys	
Product Information Description	***Product Data (Summary)***	***Submittal Reference Document***
Luminaire Designation	_	
Luminaire Manufacturer	_	
Luminaire Model Number	_	
Luminous Flux – initial	watts	
Luminaire input power—initial	lumens	
Luminaire input power—maintained	watts	
Luminaire input voltage- nominal range	volts	
LED drive current - initial	milliamps	
LED drive current - maintained	milliamps	
CCT (correlated color temperature)	kelvin	
CRI (color rendering index)	_	
EPA (effective projected area) - nominal	sq. ft.	
Luminaire Weight - nominal	lbs.	
Control Interface	○ ANSI C136.41, 7-pin	
LED Driver – dimming capability	○ Dimmable, 0-10V ○ Dimmable, DALI	
LED driver- rated life	years	
Electrical transient immunity ANSI C136.2 combination wave test level	○ Basic (6kV/3kA) ○ Enhanced (10kV/5kA) ○ Elevated (20kV/10kA)	TM-21 calculator
Vibration Test-ANSI C136.31	%	
Luminaire warranty period	○ Level 2	
IES LM-80 test duration	years	
LED lumen maintenance at 36,000 hours	hours	IES LM-80-15 report
Max. LED case temperature	degrees Celsius	ISTMT report

ELECTRICAL SPECIFICATION 1604
DIVISION OF ENGINEERING
DEPARTMENT OF TRANSPORTATION
CITY OF CHICAGO
Revised April 10, 2018

LUMINAIRE: LED, VIADUCT/ELEVATED STRUCTURE RETROFIT

SUBJECT

1. This specification states the requirements for an LED (light emitting diode) luminaire. The luminaire will be for a one-to-one replacement of existing luminaires currently in use under viaducts and mounted under CTA elevated structures. The luminaires will have adjustable trunnion brackets for mounting. The LED luminaires will be integrated into a centralized lighting management system.

GENERAL

2. (a) References:
American National Standards Institute (ANSI)

- ANSI C78.377-2015, "American National Standard for Electric Lamps—Specifications for the Chromaticity of Solid State Lighting (SSL) Products"
- ANSI C82.77-10-2014, "American National Standard for Lighting Equipment—Harmonic Emission Limits—Related Power Quality Requirements"
- ANSI C136.2-2015, "American National Standard for Roadway and Area Lighting Equipment—Dielectric Withstand and Electrical Transient Immunity Requirements"
- ANSI C136.15-2015, "American National Standard for Roadway and Area Lighting Equipment—Luminaire Field Identification"
- ANSI C136.22-2004 (R2009, R2014), "American National Standard for Roadway and Area Lighting Equipment—Internal Labeling of Luminaires"
- ANSI C136.25-2013, "American National Standard for Roadway and Area Lighting Equipment—Ingress Protection (Resistance to Dust, Solid Objects and Moisture) for Luminaire Enclosures"
- ANSI C136.30-2015, "American National Standard for Roadway and Area Lighting Equipment—Pole Vibration"

- ANSI C136.31-2015, “American National Standard for Roadway and Area Lighting Equipment – Luminaire Vibration”
- ANSI C136.37-2011, “American National Standard for Solid State Light Sources Used in Roadway and Area Lighting”

American Society for Testing and Materials (ASTM)

- ASTM B85/B85M-14, “Standard Specification for Aluminum-Alloy Die Castings”
- ASTM B209-14, “Standard Specification for Aluminum and Aluminum Alloy Sheet and Plate”
- ASTM B117-16, “Standard Practice for Operating Salt Spray (Fog) Apparatus”
- ASTM D523-14, “Standard Test Method for Specular Gloss”
- ASTM D1654-08, “Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments”
- ASTM G154-12a, “Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials”

Illuminating Engineering Society of North America (IES)

- ANSI/IES LM-63-02, “Standard File Format for Electronic Transfer of Photometric Data”
- IES LM-79-08, “Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products”
- ANSI/IES LM-80-15, “IES Approved Method: Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules”
- ANSI/IES RP-8-14, “Roadway Lighting”
- ANSI/IES RP-22-11, "Tunnel Lighting"
- IES TM-21-11 (with Addendum B), “Projecting Long Term Lumen Maintenance of LED Light Sources”

Institute of Electrical and Electronics Engineers (IEEE)

- IEEE Standard 1789-2015, “IEEE Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers”

International Electrotechnical Commission (IEC)

- IEC 60529-2004, “Degrees of Protection Provided by Enclosures (IP Code)”

Underwriters Laboratories (UL)

- ANSI/UL 1598 (3rd Edition), "Luminaires”

(b) Submittal Requirements:

The bidder, if so requested, must submit the following information pertaining to the specified luminaire within fifteen (15) days of such request:

1. Completed Table A – Submittal Form

2. Product Data Sheets.

   Luminaire data sheets – including summary product description, dimensioned outline drawings, and nominal characteristics including but not limited to: initial luminous flux (lumens), input power (watts), input voltage range (volts), LED drive current (milliamps), correlated color temperature (kelvins), color rendering index, and weight (pounds).

   LED Driver data sheet – including information described in LED Driver Requirements Section 4(c).

   LED light source data sheet

   Surge protection device data sheet - if applicable

3. Photometric Performance Data

   The manufacturer must provide photometric calculations, as part of each luminaire’s submittal package, that demonstrate the luminaire’s photometric performance will meet or exceed the photometric requirements listed in this specification. The submitted lighting calculations must include point-by-point illuminance, luminance and veiling luminance data, as well as listings of all indicated averages and ratios. Photometric reports must include the following information and be in accordance with the standards listed below:

   IES LM-79-08 photometric report that includes measured values for initial luminous flux, input power, correlated color temperature, and color rendering index.

ANSI/IES LM-63-02 electronic format photometric file that corresponds to the LM-79 report.

LM-63 photometric calculations that demonstrate compliance with the illumination requirements specified herein using the LM-63 file. Calculation grids and observer locations not specified herein must be in accordance with ANSI/IES RP-8-14.

IES TM-21-11 calculations that derive the lumen maintenance (lamp lumen depreciation or LLD) factor applied to photometric calculations specified herein.

ANSI/IES LM-80-15 and in-situ temperature measurement testing (ISTMT) reports containing data used in TM-21 calculations must also be submitted. TM-21 calculations must apply to the maximum LED case temperature from ISTMT, shall not extrapolate beyond six times the duration of available LM-80 test data, and must be submitted in the spreadsheet format of the ENERGY STAR TM-21 calculator (https://www.energystar.gov/products/spec/luminaires_specification_version_2_0_pd).

LM-79, ISTMT, and LM-80 reports must correspond directly to submitted luminaires, and must be produced by test laboratories that satisfy the Testing Laboratory Requirements of the DesignLights Consortium (www.designlights.org/content/QPL/ProductSubmit/LabTesting).

ISTMT must be conducted in accordance with the DesignLights Consortium Manufacturer's Guide (https://www.designlights.org/content/qpl/productsubmit).

ISTMT shall be conducted in an ambient temperature of 25 ± 5 °C. Ambient temperature variations above or below 25 °C shall be respectively subtracted from or added to temperatures recorded at points on the luminaire.

4. Safety Certification - file number indicating compliance with UL 1598. Applicable testing bodies are determined by the US Occupational Safety Health Administration (OSHA) as Nationally Recognized Testing Laboratories (NRTL) and include: CSA (Canadian Standards Association), ETL (Edison Testing Laboratory), and UL (Underwriters Laboratory).

5. Vibration Testing - the luminaire must be tested in accordance with ANSI C136.31 at a vibration level of 5G.

6. Product Samples - at least two samples of each luminaire that the contractor proposes to use must be submitted to the City. All samples must be representative production units and be supplied at no cost to the City.

(c) Assembly.
Each luminaire must be delivered completely assembled, wired, and ready for installation.

(d) Warranty.
The luminaire manufacturer must warrant the performance and construction of luminaires to meet the requirements of this specification, and must warrant all parts, components and appurtenances against defects due to design, workmanship or material developing within a period of ten (10) years from the date of acceptance by the City.

- Failure of 10% or more of the LED light sources (packages or arrays/modules) in a luminaire will constitute a luminaire failure.
- The warranty must apply for application on all of the City's existing electrical systems, both grounded and ungrounded.
- During the warranty period the City may, from time to time, test a random sampling of 7-10 luminaires for verification of light output per IES LM-79 and to test dimming functionality for a given luminaire population. The percentage of luminaires not performing as required in the random sampling will be applied to the total population quantity to determine the number of new luminaire replacements that must be delivered to the City by the manufacturer, without expense to the City.

(e) Manufacturing Experience and Capacity
The manufacturer must demonstrate at least a five year history of manufacturing LED roadway and outside area luminaires by providing a list of prior projects with project description, date, location, quantities and reference contact information. The manufacturer must also demonstrate the capacity to supply the quantities required for the contract in a timely man

CONSTRUCTION

3. (a) Weight. The net weight of this luminaire must not be more than 30 pounds.

(b) Housing. The housing must be precision die-formed, seam welded aluminum. The aluminum must be marine-grade (3003 alloy or equivalent).

Alternate materials will be considered. The housing must have integral heat sink characteristics, such that all enclosed components will operate within their designed operating temperatures under expected service conditions. All heat shields and heat sinks will be integral to the luminaire.

The housing will be designed to encourage water shedding. The housing must be designed to minimize dirt and bug accumulation. The housing will have the general appearance of Electrical Standard Drawing 981.

A wiring compartment capable of accepting a .75 inch threaded conduit fitting to accommodate an electrical whip must be included..

(c) Mounting brackets. Each housing must have two trunnion type brackets. One bracket must be mounted to each end panel of the housing with appropriate screws or bolts. The brackets will allow the luminaire to be positioned up to 90˚ in either direction from the horizontal. The brackets must be marked on the outside indicating the degrees of angle. The brackets will provide for positive locking in the desired position.

(d) Door and Lens. A replaceable high impact UV resistant polycarbonate drop lens will cover the LED array. This lens will be attached to a door. The door must be of the same aluminum as the housing. The door will be hinged on one side such that when opened the door will fall open toward the roadway. The other side of the door will be attached to the housing with latches, allowing tool-less entry. The door will allow easy access to the driver and terminal strip (unless the terminal strip is in a separate accessible wiring compartment).

In order to make a dustproof assembly, a gasket of silicone rubber or other specifically approved material must be provided.

(e) Hardware. All fasteners necessary to make a firm assembly must be furnished in place. All hardware must be of stainless steel, copper silicon alloy or other non-corrosive metal, and where necessary must be suitably plated to prevent electrolytic action by contact with aluminum.

(f) Finish. The luminaire must have a polyester powder coat with a minimum 2.0 mil thickness. Surface texture and paint quality will be subject to approval. Color must be as specified in the purchase order. A paint chip must be submitted as a sample upon request. The finish must exceed a rating of six per ASTM D1654 after 1000 hours of testing per ASTM B117. The coating must exhibit no greater than 30% reduction of gloss per ASTM D523 after 500 hours of QUV testing at ASTM G154 Cycle 6.

(g) Ingress Protection. The luminaire housing must have an ingress protection rating of IP54 or better as described in ANSI C136.25-2013. The optical system must have a rating of IP66 or better.

(h) The luminaire must be listed for wet locations by a U.S. Occupational Safety Health Administration (OSHA) Nationally Recognized Laboratory (NRTL) and have a safety certification and file number indicating compliance with UL 1598.

(i) The luminaire must be rated to operate between -40° to +50° Celsius.

(j) The luminaire must meet the requirements of ANSI C136.22 for internal labeling.

(k) The luminaire must be labeled for field identification according to ANSI C136.15.

ELECTRICAL COMPONENTS

4. (a) LED Optical Array. The LED arrays must be optimized for the required roadway photometrics. The arrays must be properly secured at the factory and must not require field adjustment for optimum photometric performance.

(b) Terminal Board. A terminal block of high grade molded plastic of the barrier or safety type must be mounted within the housing in a readily accessible location. It must provide all terminals needed to completely prewire all luminaire components.

The terminal board must have plated copper or plated brass, clamp-type pressure terminals of an approved type for "line" connections, to accommodate wire sizes from #12 to #8 A.W.G. The terminals for connection of internal components must be either the screw-clamp or quick disconnect type.

(c) Driver Requirements:

1. Voltage. The electronic driver must operate at a nominal input voltage range of between 120 and 277 volts, 60 Hertz. It must automatically sense the input voltage and adjust the output accordingly. The City uses nominal input voltages of 120, 208, and 240. When operated at any supply voltage between 80% and 110 % of its rated supply voltage, a driver must supply proper current and/or voltage regulation that equals or exceeds the values specified by the manufacturer.

2. Electrical Safety. Luminaires must operate at or below the Low-Risk Level, as defined in Figure 18 of IEEE 1789-2015.
3. Power Factor. The power factor of the driver over the design range of input voltages specified above must be in accordance to ANSI C82.77-2014. Power factor must be equal to or greater than .9.
4. Total Harmonic Distortion. The driver input current must have Total Harmonic Distortion (THD) specified in accordance to ANSI C82.77-2014. Total harmonic distortion must be less than 20%.
5. Thermal Protection. The driver must be thermally protected to shut off when operating temperatures reach unacceptable levels.
6. Electromagnetic Interference. Luminaire must comply with the FCC radiation emission limits for Class B digital devices given at 47 CFR 15.109.

(d) Electrical Transient Immunity.

1. Dielectric Withstand Testing. Luminaire must meet the performance requirements specified in ANSI C136.2-2015 for dielectric withstand, using the DC test level and configuration.

2. Electrical Transient Immunity. Luminaire must meet the performance requirements specified in ANSI C136.2-2015 for electrical transient immunity, using the Enhanced (10kV/5kA) combination wave test level.

3. Transient Immunity Testing Requirements.

   During electrical transient immunity testing, the device under test (DUT) must be connected to the power source through a series coupler/decoupler network(CDN), using a two-wire (hot or hot/neutral) connection between both the power supply and the CDN input and the CDN output and the DUT. If the AC main is used to power the DUT, the input waveform must be characterized and documented both before and after electrical transient immunity testing, with the DUT operating at rated full output. For pre-test DUT characterization, the diagnostic measurements must, at a minimum, include real power, input current(RMS), power factor, and current distortion factor (THD) when operating at full output.

4. Manufacturer must indicate whether failure of the electrical transient immunity system can possibly result in disconnect of power to the luminaire.

(e) Wiring. All components must be completely factory wired with non-fading, color coded leads. All wires within a single circuit path must be of the same

size. No wire nuts will be allowed. No unnecessary splices will be allowed. The use of wiring smaller than #16 AWG will require the written approval of the Commissioner. Quick disconnects must be provided for all components. All wires must be properly terminated.

(f) Control Device Receptacle and Cap.

1. Twist-lock Receptacle for a control device that meets ANSI C136.41 must be mounted in the top of the housing with provision for proper positioning of the control device.

2. 5-pin Receptacle. The luminaire control receptacle must be fully prewired and compliant with ANSI C136.41-2013.

3. 3-prong Shorting Cap that meets ANSI C136.10 must be provided.

4. Receptacle Wire Leads must all be properly terminated.

5. Receptacle repositioning. The receptacle must be able to be repositioned without the use of tools.

6. Control Devices Not Included in LED Specifications. Whereas specifications for control receptacles are included, specifications for control devices are not. The control device performance requirements are part of the lighting management system specifications in the Smart Lighting Project Technology specifications.

(f) Component Mounting. All electrical components must be securely mounted in such manner that individual components can be easily maintained or replaced. Permanent straps or tie-wraps will not be permitted. The entire assembly should be easily disconnected and removed for replacement.

PHOTOMETRIC REQUIREMENTS

5. (a) Color Temperature. The correlated color temperature must be a nominal 3000 kelvin.

(b) Lumen Maintenance. LED arrays must deliver a minimum of 90% of the initial lumen output at 36,000 hours of operation.

(c) Light Loss Factor. The light loss factor must be calculated as per IES RP-8-14 using the following three factors.

1. LED Lumen Depreciation (LLD). Calculated at 60,000 hours as per

Section 2(b)3. Luminaires with less than 10,000 hours of available LM-80 test data may be submitted for consideration, but must be indicated as such.

2. Luminaire Dirt Depreciation.(LDD). Should be .86.
3. Luminaire Ambient Temperature Factor (LATF). Should be .96.

(d) Roadway Luminance:

Average Luminance	2.5 cd/m2
Uniformity Ratio avg/min	3:1
Uniformity Ratio max/min	5:1
Max veiling Luminance	0.5

(e) Roadway Conditions. The luminaires must meet the requirements for the following physical conditions:

Right-of-way	66’
Curb-to-curb	46’
Sidewalk	10’ each side
Mounting height	13’
Tilt	45°
Setback	10’
Arm length	0’
Spacing	30’
Pavement	R3

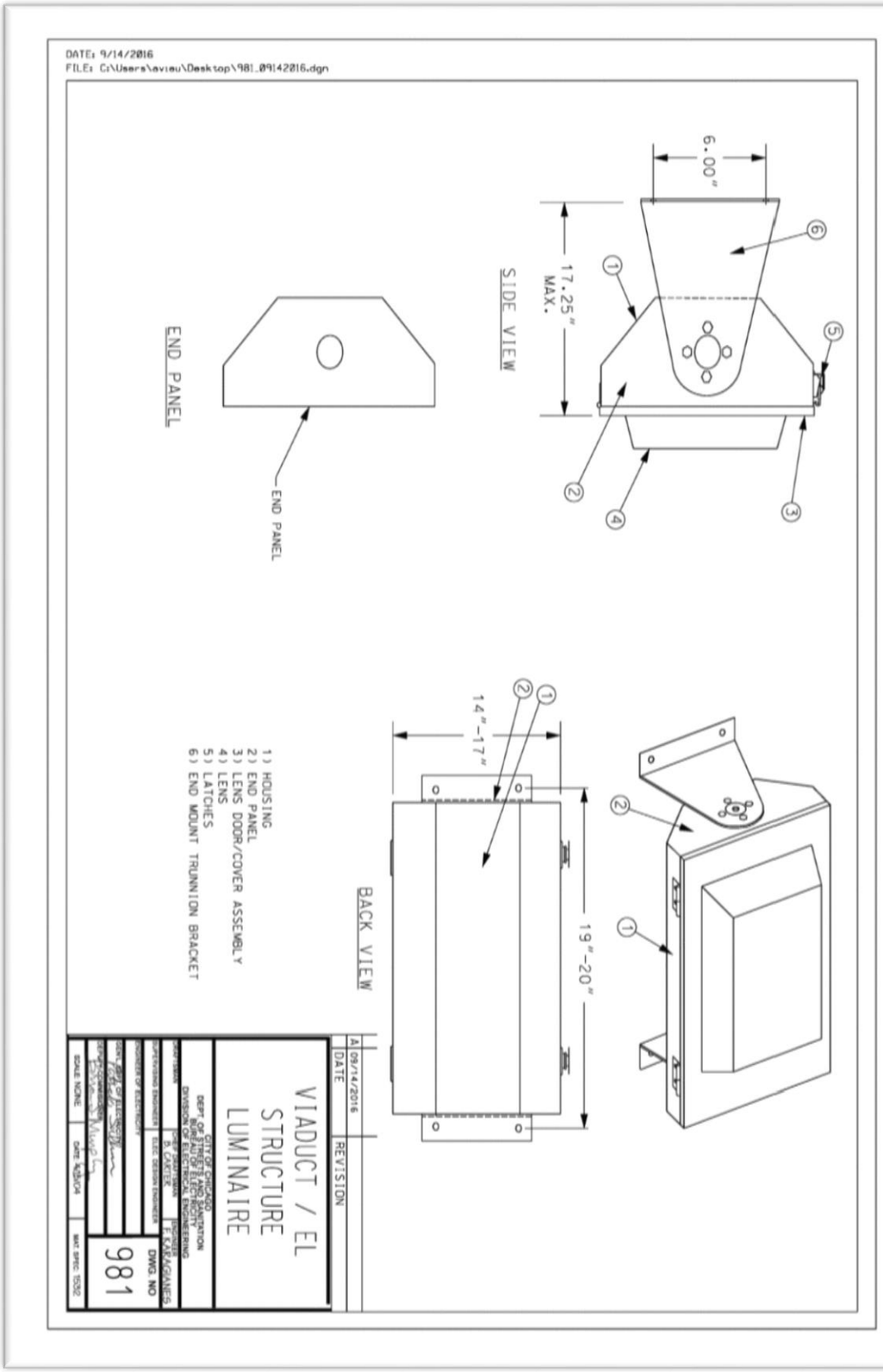
PACKAGING

7. (a) Packing. Each luminaire assembly must be securely packed in a suitable carton so as not to be damaged in shipment and handling.

(b) Marking. Each carton containing a luminaire must be clearly marked on the outside in letters not less than three-eighths (3/8) inch tall with the legend: "LUMINAIRE, LED, VIADUCT". The appropriate City Commodity Code Number, the name of the manufacturer, the date of manufacture, and the contract number under which the luminaire is furnished shall also be listed.

TABLE A
PRODUCT SUBMITTAL FORM

PRODUCT INFORMATION	DATA	UNITS/REFERENCE
Luminaire Manufacturer		
Luminaire Model Number		complete ordering information
Initial luminous flux		lumens
Initial input power		watts
Maintained input power		watts
Input voltage range		volts
Initial LED drive current		milliamps
Maintained LED drive current		milliamps
Correlated Color Temperature(CCT)		kelvin
Color rendering Index (CRI)		
Luminaire Weight		pounds
Rated Driver Life		years
Electrical Transient Immunity		kV/kA ANSI C136.2
Vibration Test		5G ANSI C136.31
Warranty period		years
IES LM-80 test duration		hours IES LM-80 Report
LED lumen maintenance at 36,000 hours		% TM-21 Calculator
Max LED Case Temperature		°C ISTMT Report


DATE: 9/14/2016
FILE: C:\Users\avieu\Desktop\981_09142016.dgn
6.00"
17.25" MAX.
SIDE VIEW
END PANEL
END PANEL
14"-17"
19"-20"
BACK VIEW
1) HOUSING
2) END PANEL
3) LENS DOOR/COVER ASSEMBLY
4) LENS
5) LATCHES
6) END MOUNT TRUNNION BRACKET
A 09/14/2016
DATE
REVISION
VIADUCT / EL
STRUCTURE
LUMINAIRE
CITY OF CHICAGO
DEPT. OF STREETS AND SANITATION
BUREAU OF ELECTRICITY
DIVISION OF ELECTRICAL ENGINEERING
F. KARAGIANES
DWG. NO
981
SCALE: NONE
MAT. SPEC. 1532

ELECTRICAL SPECIFICATION 1608
DIVISION OF ENGINEERING
DEPARTMENT OF TRANSPORTATION
CITY OF CHICAGO
REVISED OCTOBER 11, 2017

CONTROL: SMART LIGHTING, FOR ROADWAY LIGHTING, INTERNAL AND TWIST LOCK TYPE

SUBJECT

1. This specification states the requirements for smart lighting control node, consisting essentially of a control module compatible with Silver Springs Network, photocell, relay, and a surge arrester, all enclosed in an approved housing, to control the operation of roadway luminaire. The internal node is to be used for acorns, globes, gas light & teardrop luminaires. The external twist-lock node is to be used for cobra-head luminaires.

GENERAL

2. (a) Information Required. Each bidder shall submit with his proposal the following information relative to the photoelectric control he proposes to furnish.

   (1) Outline drawing.

   (2) Complete environmental, electrical, physical, and operating data on the control unit.

   (3) Data by the control node manufacturer including sensitivity, operating temperature and load rating.

   (4) Manufacturer's name and catalogue designation.

   (b) Assembly. Each control node must be delivered completely assembled, wired, and ready for installation.

   (c) Size and Weight.

   (1) Internal Node - the unit must not be more than 2.5" high, 4.25" length and 3.5" width with a maximum weight of eleven (11) ounces.

   (2) External Twist Lock Node - the unit must not be more than 5" high or 3.5" in diameter with a maximum weight of nine (9) ounces.

   (d) Smart Lighting control modules must meet or exceed all requirements of ANSI Standard C136-10-2010 for Twist Lock Controls & ANSI C136.41.2013 Dimming Control between an External Locking Type Control and Ballast or Driver. The external node must be SEL External CMS Module Part No. 8S570101-001002-1-CHI or approved equal. The internal node must be SEL Internal CMS Module Part No. 8S87138-001002-1-CHI or approved equal.

(e) Warranty. The manufacturer shall warrant every node against any defects due to design, workmanship or materials developing within a period of five (5) years after the control has been delivered. This will be interpreted particularly to mean failure of any component impairing the proper operation or protection of the unit. Any control, or part thereof, developing defects within this period must be replaced by the manufacturer at his sole expense and without cost to the City.

(f) Sample. A sample node of the manufacture intended to be furnished must be submitted within fifteen (15) business days upon receipt of a request from the Chief Procurement Officer.

(g) Compliance with Specifications. The node must conform in detail to the requirements herein stated, and to other standards and specifications, as cited, of which the most recently published revision will govern. Certified test results must be submitted to the Commissioner as indicated below, prior to shipping of nodes. All shipments not meeting specification requirements will not be accepted.

(h) Approved. Wherever "approved" is specified herein, it will be construed to mean approved by the Commissioner or the Commissioner's authorized representative.

CONSTRUCTION

3. (a) Photoconductive Cell. The photocell shall consist of a suitable substrate, a chemically inert electrode material and a thin layer of photosensitive cadmium sulfide or other acceptable photosensitive material. It must be hermetically sealed in a glass to metal package to prevent moisture and contamination damage. Plastic cased cells are not acceptable. Filtered silicon sensors in clear epoxy cases are also acceptable. Cell dissipation over a 24 hour period must not exceed the recommended allowable levels specified by the cell manufacturer. If the cell operates on D.C. an affidavit must be submitted giving the cell manufacturer's certification that such operation will not adversely affect the sensitivity, stability, or the life of the cell. The cell must not be subject to overloading due to the demand of the design circuit nor the ambient temperatures surrounding the cell. Color response of the cell or silicon sensor must be such that maximum sensitivity is in the blue-green portion of the color spectrum.

(b) Switching Relay. The ON-OFF switching operations shall be accomplished by normally closed contacts which must be opened by means of a rugged, properly rated, magnetic relay, subject to approval. The switching shall be positive and free of chatter and/or sticking of contacts. The contractor must provide test data verifying that contact chatter does not exceed 5 milliseconds when operated under loads as herein specified. The relay must have contacts of silver alloy, tungsten, or other specifically approved material.

(c) Surge Arrestor. Over voltage protection shall be provided for the control components and the load circuit by means of a metal oxide varistor (MOV) or other specifically approved type arrestor. It must limit high voltage surges to a value at

least 20% below the basic impulse insulation level (BIL in accordance with EEI-NEMA) of the control. For the button control, the MOV must be rated for a minimum of 100 joules wired line to neutral. For the twist lock control the MOV must be rated for minimum of 160 joules wired line to neutral; a secondary MOV or zener diode of at least 6 joules must be provided to protect the electronic circuit. In both the button and twist lock controls, the MOV must be mounted internally of the control housing.

(d) Printed Circuit Boards. A conformal coating shall be applied to all printed circuit boards for environmental protection.

(e) Housing. The housing shall be molded of an approved, impact resistant, UV resistant weatherproof material such as acrylic, butyrate or polycarbonate, pigmented to an approved color. The housing is required to be impact resistance greater than 1.0 ft-lbs at -40° C. Year and manufacturer must be molded in cover.

(f) Fail-Safe. Relay contacts must be normally closed so that when circuit failure occurs the lights are turned on, or remain on.

(g) Dating. A weatherproof, permanent label must be attached to each unit indicating manufacturer's name, month and year of manufacture, model and serial numbers, voltage and load ratings, and, on twist lock control, provision for marking installation and removal dates.

(h) Lead Wires.

(1) Internal Node - lead wires must be #18 AWG (Min); rated for 105^{0}C; and 12" long. They must be color coded as follows:

Red - Load
White - Neutral (on 120 volt controls)
Black - Line
Yellow - Common (on 240 volt controls)

240 volt internal node must have a permanent black on orange label 0.5"x2.0" in size that reads “240 VOLT”.

(2) External Node - the base must provide an integral, 5-pin or 7-pin NEMA Twist-Lock in accordance with ANSI C136.41. A neoprene or other approved gasket must be attached to the base to effectively seal the connections against weather, insects and dust.

CHARACTERISTICS

4. (a) Electrical. The node must be stable and reliable over the range of 105 to 305 volts A.C., at 60 cycles. The external node twist lock control's direct load rating must be 1000 watts tungsten, 1800 VA ballast; the internal node control must be rated for 1000 VA ballast. Current inrush rating of the control must be not less than 100 amperes. Control nodes must turn on/off roadway luminaires and provide 0-10V dimming for roadway luminaires capable of dimming capable of dimming used by the City of Chicago.

(b) Environmental. The control must be stable and reliable over an operating temperature range of -40°C (-40°F) to + 70°C (+158 °F).

(c) Operating Levels. Each control furnished must be pre-aged in intense light for a period of not less than 10 hours, after which it must be calibrated using a photometer whose accuracy is traceable to the N.I.S.T. 100% quality control inspection must be performed after calibration and final assembly.

(1) The internal node control must be calibrated at 120 VAC for a "turn-on" setting of .50 ± 0.1 horizontal foot candles of natural illumination with a 7-15 second turn OFF delay. The "turn-off" setting must be adjusted to one and one half (1.5) times the "turn-on" setting. Internal node controls must have a 7-15 second turn ON delay.

(2) The external node control must be calibrated at 120 VAC for a "turn-on" setting of 1.50 ± 0.30 horizontal foot candles of natural illumination with a 2-5 second turn OFF delay. The "turn-off" setting must be adjusted to one and one half (1.5) times the "turn-on" setting. The external node control must have a 1-2 second turn ON delay.

(e) Network. The control nodes must operate on an open standards secure (WiSun) IEEE 802.15.4g wireless mesh IPv6 based multi-application network compatible with Silver Springs Network. The control nodes shall support Frequency-Hopping Spread Spectrum up to 300kb/s mesh networking as well as automatic data routing with self-configuration, auto-healing & redundant uplinks. The device must be FCC compliant.

The control nodes must have full application and link-layer security with full PKI, AES-128 and -256, and embedded firewall which includes integrated multi-layer security with end-to-end encryption and capability to prohibit unauthorized access.

Internal Nodes must be able to communicate with network even when installed inside a metal housing of the luminaire.

5. (a) Procedures. Test procedures must conform to these specifications, and to ANSI Standards C136-10-2010, except as otherwise herein indicated.

(b) Performance Test. The control shall be subject to an accelerated performance test which will consist of cycling ON (30 seconds) and OFF (30 seconds) sixty times per hour at rated load for 2000 cycles. The node must not exceed the limits indicated for the nominal or rated operating levels, and relay contact points must not stick or show high resistance due to excessive pitting and/or erosion.

(c) Dielectric Strength Test. The control unit complete with enclosure shall be subject to a D.C. hypot test for dielectric strength. It must successfully withstand a 5.0 KV test for one (1) minute dry.

(d) Drop Test. The control must be capable of withstanding a drop of 3 feet to a concrete floor without causing damage to the housing or changing electrical operation.

(e) Surge Protection Test. The control shall be subject to a test for surge protection in accordance with UL 1449 and ANSI C62. By means of a surge generator, a 6.0 KV, 1.2 x 50 microsecond voltage wave impulse test must be made. The surge test must have a short circuit current average of at least 3 KA for 8.0 x 20 microseconds. The control must withstand the impulse testing, and change in calibration levels must not exceed the limits indicated for the nominal or rated operating levels.

(f) Temperature and Humidity Tests. The control will be subject to specified calibration tests immediately following conditioning of the control at extremes of temperature and humidity, as indicated below:

(1) Condition the control for a period of 24 hours at 98% relative humidity and 70° C temperature.

(2) Condition the control for a period of 10 hours at -40° C (-40° F).

(g) Calibration Test. After completion of all specified testing, the control unit must be recalibrated and must be within the operating parameters of this specification. During this test, the manufacturer must demonstrate that there is no cycling during either "turn-on" or "turn-off."

(h) Testing. One (1) unit from each lot of 500 nodes, with a minimum of 2 nodes per contract, will be subject to test. In the event any node fails to meet test requirements, the entire lot will be subject to rejection, except that the manufacturer, may subject a minimum of five (5) additional nodes in the lot to test and if all fulfill the requirements, the lot will be accepted. Should any of the additional five (5) nodes fail, then the entire lot will be rejected. Certified test reports must be submitted to the Commissioner for approval prior to shipment of material. All units subjected to test will remain the property of the Contractor and may not be included as part of this contract.

PACKAGING

6. (a) Carton. Each smart lighting control node must be individually packed in a carton of adequate strength and properly secured and protected to prevent damage to the unit during shipment, handling and storage.

(b) Marking. Each carton into which a number of individually packed photoelectric units are packed must be clearly marked on the outside in letters not less than one-quarter (1/4) inch tall with the legend "SMART LIGHTING INTERNAL CONTROL NODE" or "SMART LIGHTING EXTERNAL CONTROL NODE" (as appropriate), preceded by the number of units in the carton in numbers of the same height as the letters: volt-ampere lamp load rating, voltage, manufacturer's name and catalogue number, contract or order number, and shipping date.

ELECTRICAL SPECIFICATION No. 1612
CITY OF CHICAGO
DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING
DECEMBER 7, 2017

OUTDOOR LED LUMINAIRE SPECIFICATION:
ORNAMENTAL ARTERIAL STREETS (Acorn)

I. SUBJECT

A. This specification states the requirements for an ornamental Acorn LED street light luminaire. The luminaire shall be for arterial street lighting. The overall shape of the luminaire shall be historic acorn. The LED luminaires will be integrated into a centralized lighting management system. The luminaire shall be mounted on a tenon at a mounting height of 14, 16 or 23 feet above grade and be as similar as an IES Type II/III medium non-cutoff distribution. The luminaire will be used to provide roadway lighting for arterial streets.

II. GENERAL

A. References

American National Standards Institute (ANSI)

- ANSI C78.377-2015, "American National Standard for Electric Lamps—Specifications for the Chromaticity of Solid State Lighting (SSL) Products"
- ANSI C82.77-10-2014, "American National Standard for Lighting Equipment—Harmonic Emission Limits—Related Power Quality Requirements"
- ANSI C136.2-2015, "American National Standard for Roadway and Area Lighting Equipment—Dielectric Withstand and Electrical Transient Immunity Requirements"
- ANSI C136.10-2010, "American National Standard for Roadway and Area Lighting Equipment—Locking-Type Control Devices and Mating Receptacles—Physical and Electrical Interchangeability and Testing"
- ANSI C136.15-2015, "American National Standard for Roadway and Area Lighting Equipment—Luminaire Field Identification"
- ANSI C136.22-2004 (R2009, R2014), "American National Standard for Roadway and Area Lighting Equipment—Internal Labeling of Luminaires"
- ANSI C136.25-2013, "American National Standard for Roadway and Area Lighting Equipment—Ingress Protection (Resistance to Dust, Solid Objects and Moisture) for Luminaire Enclosures"
- ANSI C136.31-2015, "American National Standard for Roadway and Area Lighting Equipment—Luminaire Vibration"
- ANSI C136.37-2011, "American National Standard for Solid State Light Sources Used in Roadway and Area Lighting"
- ANSI C136.41-2013, "American National Standard for Roadway and Area Lighting Equipment–Dimming Control Between an External Locking Type Control and Ballast or Driver"
- ASTM B85/B85M-14, "Standard Specification for Aluminum-Alloy Die Castings"
- ASTM B117-16, "Standard Practice for Operating Salt Spray (Fog) Apparatus"
- ASTM D523-14, "Standard Test Method for Specular Gloss"
- ASTM D1654-08, "Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments"
- ASTM G154-12a, "Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials"

Illuminating Engineering Society of North America (IES)

- ANSI/IES LM-63-02, “Standard File Format for Electronic Transfer of Photometric Data”
- IES LM-79-08, “Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products”
- ANSI/IES LM-80-15, “IES Approved Method: Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules”
- ANSI/IES RP-8-14, “Roadway Lighting”
- IES TM-21-11 (with Addendum B), “Projecting Long Term Lumen Maintenance of LED Light Sources”

Institute of Electrical and Electronics Engineers (IEEE)

- IEEE Std 1789-2015, “IEEE Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers”

International Electrotechnical Commission (IEC)

- IEC 60929:2011 (with Amendment 1), “AC and/or DC-supplied electronic control gear for tubular fluorescent lamps - Performance requirements”

Underwriters Laboratories (UL)

- ANSI/UL 1598 (3rd Edition), "Luminaires”

B. Submittal Requirements:

The Contractor must submit the following information pertaining to each specified luminaire type within fifteen (15) days of request:

A. Completed ATTACHMENT B – Submittal Form

B. Product Data Sheets.

a) Luminaire data sheets – including summary product description, dimensioned outline drawings, and nominal characteristics including but not limited to: initial luminous flux (lumens), input power (watts), input voltage range (volts), LED drive current (milliamps), correlated color temperature (kelvins), color rendering index, effective projected area (square feet) and weight (pounds).

b) LED Driver data sheet – including information described in LED Driver Requirements Section III-D-3.

c) LED light source data sheet

d) Surge protection device data sheet - if applicable

C. Photometric Performance Data

The manufacturer must provide photometric calculations, as part of each luminaire’s submittal package, that demonstrate the luminaire’s photometric performance will meet or exceed the photometric requirements listed in this specification. The submitted lighting calculations must include point-by-point illuminance, luminance and veiling luminance data, as well as listings of all indicated averages and ratios. Photometric reports must include the following information and be in accordance with the standards listed below:

IES LM-79-08 photometric report that includes measured values for initial luminous flux,

a) input power, correlated color temperature, and color rendering index.

b) ANSI/IES LM-63-02 electronic format photometric file that corresponds to the LM-79 report.

c) LM-63 photometric calculations that demonstrate compliance with the illumination requirements specified herein using the LM-63 file. Calculation grids and observer locations not specified herein must be in accordance with ANSI/IES RP-8-14.

d) IES TM-21-11 calculations that derive the lumen maintenance (lamp lumen depreciation or LLD) factor applied to photometric calculations specified herein.

- ANSI/IES LM-80-15 and in-situ temperature measurement testing (ISTMT) reports containing data used in TM-21 calculations must also be submitted.
- TM-21 calculations must apply to the maximum LED case temperature from ISTMT, shall not extrapolate beyond six times the duration of available LM-80 test data, and must be submitted in the spreadsheet format of the ENERGY STAR TM-21 calculator (https://www.energystar.gov/products/spec/luminaires_specification_version_2_0_pd).

LM-79, ISTMT, and LM-80 reports must correspond directly to submitted luminaires, and must be produced by test laboratories that satisfy the Testing Laboratory Requirements of the Design Lights Consortium (www.designlights.org/content/QPL/ProductSubmit/LabTesting).

ISTMT must be conducted in accordance with the Design Lights Consortium Manufacturer's Guide (https://www.designlights.org/content/qpl/productsubmit).

ISTMT shall be conducted in an ambient temperature of 25 ± 5 °C. Ambient temperature variations above or below 25 °C shall be respectively subtracted from or added to temperatures recorded at points on the luminaire.

D. Safety Certification - file number indicating compliance with UL 1598. Applicable testing bodies are determined by the US Occupational Safety Health Administration (OSHA) as Nationally Recognized Testing Laboratories (NRTL) and include: CSA (Canadian Standards Association), ETL (Edison Testing Laboratory), and UL (Underwriters Laboratory).

E. Vibration Testing - the luminaire must comply with ANSI C136.31 at Vibration Test Level 1 (1.5 G).

F. Product Sample - a sample of the luminaire that the contractor proposes to use must be submitted to the City. Sample must be representative production units and be supplied at no cost to the City.

C. Assembly.

Luminaire must be delivered completely assembled, wired, and ready for installation.

D. Warranty.

The luminaire manufacturer must warrant the performance and construction of luminaires to meet the requirements of this specification, and must warrant all parts, components and appurtenances against defects due to design, workmanship or material developing within a period of ten (10) years from the date of acceptance by the City.

- The inability of a luminaire to be dimmed will constitute a luminaire failure.
- Failure of 10% or more of the LED light sources (packages or arrays/modules) in a luminaire will constitute a luminaire failure.
- The warranty must apply for application on all of the City's existing electrical systems, both grounded and ungrounded.

During the warranty period the City may, from time to time, test a random sampling of 10-20 luminaires for Electrical

- verification of light output per IES LM-79 and to test dimming functionality for a given luminaire population. The percentage of luminaires not performing as required in the random sampling will be applied to the total population quantity to determine the number of new luminaire replacements that must be delivered to the City by the manufacturer, without expense to the City.

E. Manufacturing Experience and Capacity

The manufacturer must demonstrate at least a five year history of manufacturing LED roadway and outside area luminaires by providing a list of prior projects with project description, date, location, quantities and reference contact information. The manufacturer must also demonstrate the capacity to supply the quantities required for the contract in a timely manner.

III. CONSTRUCTION

A. Capital and Finial

1. Material

a) Each capital and finial shall be cast aluminum conforming to American Die casting Standard ADC-1-C9-83 grade 380.

b) The capital shall fit over a 3" high by 3" O.D. tenon.

c) The capital attachment to the tenon shall provide the structural integrity to hold the luminaire firmly in place during the vibrations anticipated due to passing heavily loaded vehicles, wind loading, and inclement weather.

d) A minimum of 3/16" thickness of metal must be provided where the set screws are inserted to minimize the possibility of stripping the threads when the set screws are tightened into place.

e) The set screws must be 5/16-18 stainless steel hex head screws. A minimum of three (3) set screws must be provided, evenly spaced at 120° apart.

f) The finial shall be securely attached to the acorn globe such that it will remain in place during the vibrations described above.

g) The Casting must have smooth external surfaces free from protuberances, dents, cracks or other imperfections marring their appearance. Welding or plugging of casting defects is prohibited.

h) Each casting must be die cast or made by the permanent mold process; sand castings will not be acceptable.

i) Minimum thickness will be 3/16", and will be uniform within each casting and throughout all castings in an entire order. Inconsistencies in casting thickness will be cause for rejection of the entire lot.

2. Appearance

a) The housing will be of a similar design as manufactured by Spring City, or Sternberg. Similar designs must be approved by the Commissioner. The Commissioner’s decision of what constitutes a similar design will be final.

b) The capital shall conform in appearance to that shown on Electrical Standard Drawing Number 912.

B. Cast Housing and Fitter Painting

1. Oil and Grease Removal
   a) All metal surfaces must be washed with an alkaline detergent to remove any oils or grease.

2. Chemical Pretreatment

   a) The cleaned metal surfaces must be rinsed with de-ionized water
   b) Treated with a hot, pressurized phosphate wash and sealer
   c) Rinsed again with de-ionized water, and then dried by convection heat.

3. Exterior and Interior Coat

   a) A thermosetting, weathering, polyester powder coat must be applied electrostatically to all cleaned and treated surfaces to a uniform four mil thickness in a one coat application.
   b) This powder coat must be cured in a convection oven at a minimum 400ºF to form a high molecular weight fusion bonded finish.

4. Alternate Methods

   a) Alternate coating methods may be reviewed and tested on a case-by-case basis. However, no coating method will be accepted unless the Commissioner judges such alternate to be equal to the coating herein specified

5. Durability

   a) Both the exterior and interior coats must be capable of passing 1,000 hours of salt spray exposure as per ASTM B117 in a 5% Na Cl (by weight) solution at 95ºF and 95% relative humidity without blistering.
   b) Before test, the panel must be scribed with an "X" down to bare metal.

6. Coating Measurement
   a) Measurement of coating thickness must be done in accordance with SSPC-Pa 2-73T, "Measurement of Dry Paint Thickness with Magnetic Gauges", except that the lowest "single spot measurement" must not be less than 3.0 mils.

7. Color
   a) Preferred color will be gloss black. A 4" square color chip sample must be submitted for approval prior to fabrication.
   b) The chip sample must be of the same material as the capital, and must include the manufacturer's name and the manufacturer's color name as well.
   c) The sample must also include any other information which will be required to purchase the same color for the masts, mast arms and split pedestal bases.

C. Optical Assembly

1. Acorn Globe and Reflector

   a) The Globe shall be constructed of clear, V825 HID acrylic utilizing a slip-fit 1/2" overlap, two piece which eliminates a "butt-glue" seam appearance.

   b) The Globe must conform to that shown on Electrical Standard Drawing 912.

c) The bottom optical section of the globe must have a neck opening of 7-1/4" at the smallest diameter and an outside dimension of 8" at the bottom; be a minimum of 12-3/4" in height and 16 1/2" in width at the top.

d) The top section of the globe must be "Victorian" in appearance; a minimum of 13" in height and 16.313" in width with 100 horizontal prisms to evenly diffuse light. If so requested, a full top reflector of the same diameter as the globe shall be installed between the halves and secured to the globe. The top and bottom sections shall be secured in a slip-fit overlap design using four #10 -24 x 5/8 stainless steel pan head screws with four aluminum nutserts providing a mechanical lock. In addition, a sealant must be applied to the two halves to provide a dust-proof seal.

e) The globe shall be mounted with four 5/16-18 hex head, stainless steel bolts with stop nuts mounted into the die cast fixture housing.

f) They must securely contact an aluminum globe neck ring connected to the acorn globe. The globe must be clearly marked and keyed so that it will be properly installed to provide the required house side/street side photometrics. The mounting must afford the rigidity necessary to prevent the globe from twisting or rattling when subjected to the vibrating forces of passing elevated trains or heavily loaded vehicles. The mounting must not preclude any globe from being mutually interchangeable with any other globe intended for this function.

g) A top reflector and a house-side reflector shall be provided.

h) These reflectors shall be mounted to a removable bracket.

i) The small dome shaped top reflector, approximately 6.5 inches in diameter and 3 inches deep shall be mounted on the bracket and attached by a spring clamp, or other suitable means, to the lamp socket or lamp socket holder.

j) The side reflector shall be mounted to the same bracket. The reflectors shall be constructed of aluminum and polished to a high specular finish. Reflectance of the reflecting surfaces shall not be less than 75%. Measurements shall be made with a reflectometer using the fiber-optic method.

k) If so ordered in the line item of a contract, a full top reflector will be provided as part of the globe. This reflector will be inserted between the two halves of the globe and permanently sealed to the globe halves. This reflector will not allow any light from the lamp to enter the top half of the globe.

D. Electrical Components

1. LED Optical Array.

a) The LED arrays shall be optimized for the required roadway photometrics. The arrays must be properly secured at the factory and must not require field adjustment for optimum photometric performance.

b) The optical assembly shall consist of the LED array, the refractor, the refractor holder-door, gasketing, and all associated items.

c) The LED optical assembly shall be rated IP66 for ingress protection for dust and water.

d) The optical unit as a whole must provide as similar as an IES Medium Cut-off Type II/III distribution.

2. Terminal Block

a) A terminal block of high grade board of molded phenolic plastic shall be mounted to the capital in a readily accessible location.

b) Terminal block wiring; all necessary terminals, pre-wired to all luminaire components, must be provided.

c) Terminal block terminals must have copper plated or brass plated, clamp-type pressure connectors of an approved type for "line" connections, to accommodate wire sizes from #12 to #8 A.W.G.

d) Terminal block terminals for internal component connections must be either the screw-clamp or quick disconnect type.

3. LED Driver:

a) Voltage.
- The electronic driver must operate at an input voltage range of between 120 and 277 volts, 60 Hertz.
- It must automatically sense the input voltage and adjust the output accordingly.
- The City uses nominal input voltages of 120, 208, and 240 for street lighting.
- When operated at any supply voltage between 80 percent and 110 percent of its rated supply voltage and at rated input frequency, a driver shall provide current and/or voltage regulation that equals or exceeds the values specified by the manufacturer.

b) Electrical Safety. Luminaires must operate at or below the Low-Risk Level, as defined in Figure 18 of IEEE 1789-2015. This requirement must be satisfied across the dimming range.

c) Power Factor (PF). The power factor of the driver over the design range of input voltages specified above must be in accordance to ANSI C82.77-2014. PF must be ≥ 0.9.

d) Total Harmonic Distortion (THD). The driver input current must have specified THD in accordance to ANSI C82.77-2014. THD must be $\leq 32\%$.

e) Thermal Protection. The driver must be thermally protected to shut off when operating temperatures reach unacceptable levels.

f) Electromagnetic Interference. Luminaire must comply with the FCC radiation emission limits for Class B digital devices given at 47 CFR 15.109.

g) Electrical Transient Immunity:

- Dielectric Withstand Testing - luminaire must meet the performance requirements specified in ANSI C136.2-2015 for dielectric withstand, using the DC test level and configuration.

- Electrical Transient Immunity - luminaire must meet the performance requirements specified in ANSI C136.2-2015 for electrical transient immunity, using the Enhanced (10 kV / 5 kA) combination wave test level.

- Transient Immunity Testing Requirements:

  - During electrical transient immunity testing, the device under test (DUT) must: be connected to the power source through a series coupler/decoupler network (CDN), using a two-wire (hot or hot/neutral) connection between both the power supply and CDN input and the CDN output

and DUT.

- If AC mains is used to power the DUT, the input waveform must be characterized and documented both before and after electrical transient immunity testing, with the DUT operating at rated full output.

- For Pre-Test DUT Characterization, the diagnostic measurements shall, at a minimum, include the following: real power, input current (RMS; Root-Means-Square), power factor, and current distortion factor (THD-I Total Harmonic Distortion) when operating at rated full output.

- Manufacturer must indicate on submittal form whether failure of the electrical transient immunity system can possibly result in disconnect of power to luminaire.

h) Dimming Capability. The driver must be capable of dimming. The dimming range must be 10% to 100% of full output. The digital lighting interface used for dimming must be DALI (Digital Addressable Lighting Interface) as per the requirements of IEC 62386. There must be a minimum of 100 dimming steps between the top and bottom of the dimming range.

4. Wiring.

a) All components must be completely factory wired with non-fading, color coded leads. These leads must be insulated with an approved class of insulation and must be #16 AWG conductor at a minimum.

b) All wires within a single circuit path must be of the same size.

c) No wire-nut splicing will be allowed.

d) No unnecessary splices will be allowed.

e) Quick disconnects must be provided for all components.

f) All wires must be properly terminated.

5. Control Device Receptacle and Cap.

a) Twist-lock Receptacle for a control device that meets ANSI C136.41 must be mounted in the top of the housing or appropriate location with provision for proper positioning of the control device.

b) 7-pin Receptacle. The luminaire control receptacle must be fully prewired and compliant with ANSI C136.41.

c) 3-prong Shorting Cap that meets ANSI C136.10 must be provided.

d) Receptacle Wire Leads must all be properly terminated.

e) Receptacle repositioning. The receptacle must be able to be repositioned without the use of tools.

f) Control Devices Not Included in LED Specifications. Whereas specifications for control receptacles are included, specifications for control devices are not. The control device performance requirements are part of the lighting management system specifications in the Smart Lighting Project Technology specifications

6. Component Mounting.

All electrical components must be securely mounted in such manner that individual components can

be easily maintained or replaced. Permanent straps or tie-wraps will not be permitted. The entire assembly should be easily disconnected and removed for replacement.

IV. PHOTOMETRIC REQUIREMENTS

A. Light Pollution.

To limit light pollution, the submitted luminaires must not emit any light above the horizon (0 lumens at angles ≥ 90° from luminaire nadir).

B. Lumen Maintenance.

1. LED arrays must deliver a minimum of 90% of initial lumen output at 36,000 hours of operation.

2. Light Loss Factor (LLF) < 1.0. Calculations for maintained values, i.e. LLF = LLD x LDD x LAT.

a) Lamp Lumen Depreciation (LLD) calculated at 60,000 hours as per Section II-B-3-d above,
b) Luminaire Dirt Depreciation (LDD) ≤0.90, and
c) Luminaire Ambient Temperature (LAT) ≤0.96

Luminaires with less than 10,000 hours of available LM-80 test data may be submitted for consideration but must be clearly indicated as such.

C. Color Attributes

1. Color Rendering Index (CRI) shall be no less than 65.

2. Nominal Correlated Color Temperature (CCT) shall be 3000K as defined by ANSI C78.377 and described below:

Manufacturer-Rated Nominal CCT (K)	Allowable IES LM-79 Chromaticity Values	
	Measured CCT (K)	Measured Duv
3000	2870 to 3220	-0.006 to 0.006

A. City of Chicago Typical Ornamental Lighting Contexts

ATTACHMENT A (below) lists the photometric performance requirements for luminaires used in the following typical municipal outdoor arterial ornamental lighting applications:

- Arterial Streets – two-sided opposite pole spacing
- Arterial Streets – two-sided staggered pole spacing

ATTACHMENT A – Photometric Performance Requirements

TYPICAL LIGHTING CONTEXT	ARTERIAL		
POLE CONFIGURATION*	OPPOSITE	STAGGERED	
RIGHT OF WAY (Width)	80 ft.	66 ft.	66 ft.
IES PAVEMENT CLASS	R3	R3	R3
STREET WIDTH (Curb to Curb)	60 ft.	48 ft.	48 ft.
LANES (Incl. Parking &Median)	6	4	4
PARKWAY (Width)	4 ft.	N/A	N/A
SIDEWALK (Width)	6 ft.	9 ft.	9 ft.
HEIGHT TO LUMINAIRE	23 ft.	23 ft.	16 ft.
MAST ARM LENGTH	1ft.	1ft.	1ft.
POLE SETBACK (From Curb to Center of Pole)	4ft.	4ft.	4ft.
IN-LINE POLE SPACING	125 ft.	200 ft.	X?x ft.
LUMINAIRE REQUIREMENTS	OPPOSITE	STAGGERED	
Max Input Power - Default /Normal Luminance (Watts)	180	180	180
Default/Normal AVG. Luminance (cd/m^2)	≥1.7	≥1.7	≥1.7
AVG/MIN Uniformity Ratio	≤ 3:1	≤ 3.5:1	≤ 3.5:1
MAX/MIN Uniformity Ratio	≤ 5:1	≤ 6:1	≤ 6:1
MAX Veiling Luminance Ratio	≤ 0.5	≤ 0.5	≤ 0.5
AVG. Boosted Luminance (cd/m^2) [Add-Alternate]	≥2.5	≥2.5	≥2.5
SIDEWALK			
Default AVG. Horizontal Illuminance (fc)	≥0.50	≥0.50	≥0.50
AVG.MIN Uniformity Ratio (Horizontal Illuminance)	≤ 4:1	≤ 4:1	≤ 4:1
LIGHT TRESPASS RESTRICTIONS - (as measured in a vertical plane 10' beyond ROW ≤3' height)			
MAX Vertical Illuminance	≤ 0.3	≤ 0.30	≤ 0.30

ATTACHMENT B - Product Submittal Form

Lighting Context	**e.g. Arterial Ornamental Wide**			
Product Information Description	***Product Data (Summary)***			***Submittal Reference Document***
Luminaire Designation				
Luminaire Manufacturer				
Luminaire Model Number				
Luminous Flux – initial			lumens	
Luminaire input power—initial			watts	
Luminaire input power—maintained			watts	
Luminaire input voltage- nominal range			volts	
LED drive current - initial			milliamps	
LED drive current - maintained			milliamps	
CCT (correlated color temperature)			kelvin	
CRI (color rendering index)				
EPA (effective projected area) - nominal			sq. ft.	
Luminaire Weight - nominal			lbs.	
Control Interface			☐ ANSI C136.41, 7-pin	
LED Driver – dimming capability	☐ Dimmable, 0-10V		☐ Dimmable, DALI	
LED driver- rated life			years	
Electrical transient immunity ANSI C136.2 combination wave test level	☐ Basic (6kV/3kA)	☐ Enhanced (10kV / 5kA)	☐ Elevated (20kV/10kA)	
Vibration Test-ANSI C136.31			☐ Level 2	
Luminaire warranty period			years	
IES LM-80 test duration			hours	IES LM-80-15 report
LED lumen maintenance at 36,000 hours			%	TM-21 calculator
Max. LED case temperature			degrees Celsius	ISTMT report

ELECTRICAL SPECIFICATION No. 1613
CITY OF CHICAGO
DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING
Revised July 18, 2018

OUTDOOR LED LUMINAIRE SPECIFICATIONS:
RESIDENTIAL STREETS, ALLEYS, & ARTERIAL STREETS (Cobra Head)

(i) SUBJECT

a. This specification states the requirements for non-ornamental Light Emitting Diode (LED) outdoor lighting luminaires. The specified LED luminaires will be used to replace existing High Pressure Sodium (HPS) and Ceramic Metal Halide (CMH) luminaires on Chicago residential streets, arterial streets, and alleys. The LED luminaires will be integrated into a centralized lighting management system.

(ii) GENERAL

a. References

American National Standards Institute (ANSI)

- ANSI C78.377-2015, "American National Standard for Electric Lamps—Specifications for the Chromaticity of Solid State Lighting (SSL) Products"
- ANSI C82.77-10-2014, "American National Standard for Lighting Equipment—Harmonic Emission Limits—Related Power Quality Requirements"
- ANSI C136.2-2015, "American National Standard for Roadway and Area Lighting Equipment—Dielectric Withstand and Electrical Transient Immunity Requirements"
- ANSI C136.10-2010, "American National Standard for Roadway and Area Lighting Equipment—Locking-Type Control Devices and Mating Receptacles—Physical and Electrical Interchangeability and Testing"
- ANSI C136.15-2015, "American National Standard for Roadway and Area Lighting Equipment—Luminaire Field Identification"
- ANSI C136.22-2004 (R2009, R2014), "American National Standard for Roadway and Area Lighting Equipment—Internal Labeling of Luminaires"
- ANSI C136.25-2013, "American National Standard for Roadway and Area Lighting Equipment—Ingress Protection (Resistance to Dust, Solid Objects and Moisture) for Luminaire Enclosures"
- ANSI C136.30-2015, "American National Standard for Roadway and Area Lighting Equipment—Pole Vibration"
- ANSI C136.31-2015, "American National Standard for Roadway and Area Lighting Equipment—Luminaire Vibration"

- ANSI C136.37-2011, "American National Standard for Solid State Light Sources Used in Roadway and Area Lighting"
- ANSI C136.41-2013, "American National Standard for Roadway and Area Lighting Equipment–Dimming Control Between an External Locking Type Control and Ballast or Driver"

- ASTM B85/B85M-14, “Standard Specification for Aluminum-Alloy Die Castings”
- ASTM B117-16, “Standard Practice for Operating Salt Spray (Fog) Apparatus”
- ASTM D523-14, “Standard Test Method for Specular Gloss”
- ASTM D1654-08, “Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments”
- ASTM G154-12a, “Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials”

Illuminating Engineering Society of North America (IES)

- ANSI/IES LM-63-02, “Standard File Format for Electronic Transfer of Photometric Data”
- IES LM-79-08, “Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products”
- ANSI/IES LM-80-15, “IES Approved Method: Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules”
- ANSI/IES RP-8-14, “Roadway Lighting”
- IES TM-21-11 (with Addendum B), “Projecting Long Term Lumen Maintenance of LED Light Sources”

Institute of Electrical and Electronics Engineers (IEEE)

- IEEE Std 1789-2015, “IEEE Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers”

International Electrotechnical Commission (IEC)

- IEC 60929:2011 (with Amendment 1), “AC and/or DC-supplied electronic control gear for tubular fluorescent lamps - Performance requirements”

Underwriters Laboratories (UL)

- ANSI/UL 1598 (3rd Edition), "Luminaires”

b. Submittal Requirements:

The Contractor must submit the following information pertaining to each specified luminaire type within fifteen (15) days of request:

i. Completed ATTACHMENT G – Submittal Form

ii. Product Data Sheets.

1. Luminaire data sheets – including summary product description, dimensioned outline drawings, and nominal characteristics including but not limited to: initial luminous flux (lumens), input power (watts), input voltage range (volts), LED drive current (milliamps), correlated color temperature (kelvins), color rendering index, effective projected area (square feet) and weight (pounds).

LED Driver data sheet – including information described in LED Driver

2. Requirements Section III-I-3.

3. LED light source data sheet

4. Surge protection device data sheet - if applicable

iii. Photometric Performance Data

The manufacturer must provide photometric calculations, as part of each luminaire's submittal package, that demonstrate the luminaire's photometric performance will meet or exceed the photometric requirements listed in this specification. The submitted lighting calculations must include point-by-point illuminance, luminance and veiling luminance data, as well as listings of all indicated averages and ratios. Photometric reports must include the following information and be in accordance with the standards listed below:

1. IES LM-79-08 photometric report that includes measured values for initial luminous flux, input power, correlated color temperature, and color rendering index.

2. ANSI/IES LM-63-02 electronic format photometric file that corresponds to the LM-79 report.

3. LM-63 photometric calculations that demonstrate compliance with the illumination requirements specified herein using the LM-63 file. Calculation grids and observer locations not specified herein must be in accordance with ANSI/IES RP-8-14.

4. IES TM-21-11 calculations that derive the lumen maintenance (lamp lumen depreciation or LLD) factor applied to photometric calculations specified herein.

- ANSI/IES LM-80-15 and in-situ temperature measurement testing (ISTMT) reports containing data used in TM-21 calculations must also be submitted.
- TM-21 calculations must apply to the maximum LED case temperature from ISTMT, shall not extrapolate beyond six times the duration of available LM-80 test data, and must be submitted in the spreadsheet format of the ENERGY STAR TM-21 calculator (https://www.energystar.gov/products/spec/luminaires_specification_version_2_0_pd).

LM-79, ISTMT, and LM-80 reports must correspond directly to submitted luminaires, and must be produced by test laboratories that satisfy the Testing Laboratory Requirements of the DesignLights Consortium (www.designlights.org/content/QPL/ProductSubmit/LabTesting).

ISTMT must be conducted in accordance with the DesignLights Consortium Manufacturer's Guide (https://www.designlights.org/content/qpl/productsubmit).

ISTMT shall be conducted in an ambient temperature of 25 ± 5 °C. Ambient temperature variations above or below 25 °C shall be respectively subtracted from or added to temperatures recorded at points on the luminaire.

Safety Certification - file number indicating compliance with UL 1598. Applicable testing bodies are determined by the US Occupational Safety Health Administration (OSHA) as Nationally Recognized Testing Laboratories (NRTL) and include: CSA (Canadian Standards Association), ETL (Edison Testing

iv. Laboratory), and UL (Underwriters Laboratory).

v. Vibration Testing - the luminaire must comply with ANSI C136.31 at Vibration Test Level 2 (3.0 G).

vi. Product Samples - at least two samples of each luminaire that the contractor proposes to use must be submitted to the City. All samples must be representative production units and be supplied at no cost to the City.

c. Assembly.

Each luminaire must be delivered completely assembled, wired, and ready for installation.

d. Warranty.

The luminaire manufacturer must warrant the performance and construction of luminaires to meet the requirements of this specification, and must warrant all parts, components and appurtenances against defects due to design, workmanship or material developing within a period of ten (10) years from the date of acceptance by the City.

- The inability of a luminaire to be dimmed will constitute a luminaire failure.
- Failure of 10% or more of the LED light sources (packages or arrays/modules) in a luminaire will constitute a luminaire failure.
- The warranty must apply for application on all of the City's existing electrical systems, both grounded and ungrounded.
- During the warranty period the City may, from time to time, test a random sampling of 10-20 luminaires for verification of light output per IES LM-79 and to test dimming functionality for a given luminaire population. The percentage of luminaires not performing as required in the random sampling will be applied to the total population quantity to determine the number of new luminaire replacements that must be delivered to the City by the manufacturer, without expense to the City.

e. Manufacturing Experience and Capacity

The manufacturer must demonstrate at least a five year history of manufacturing LED roadway and outside area luminaires by providing a list of prior projects with project description, date, location, quantities and reference contact information. The manufacturer must also demonstrate the capacity to supply the quantities required for the contract in a timely manner.

(iii) CONSTRUCTION

a. Weight

The net weight of these luminaires must not be more than 30 pounds.

b. Housing.

The preferred luminaire housing material is die-cast aluminum alloy meeting ASTM Specification A380. Alternate materials may be considered. The housing must enclose the mounting hardware, LED arrays, control receptacle, terminal board, and electronic driver. The housing must include a surface to facilitate leveling with a spirit level. The housing must have integral heat sink characteristics, such that all enclosed components will operate within their designed operating temperatures under expected service conditions. No external or removable heat shields or heat sinks; are permitted. The housing must be designed to encourage water shedding. The housing must be designed to minimize dirt and bug accumulation on the optic surface.

c. Mounting Provisions.

The luminaire must include a heavy gauge slip fitter clamping assembly suitable for secure attachment over the end of a two (2) inch 2" IP (2.375" OD) steel pipe with an approved means of clamping it firmly in mounting bracket. The slip fitter mounting clamp must contain an approved shield around the pipe entrance to block the entry of birds.

d. Access Door-Panel.

An access door panel allowing access to the terminal strip and LED driver must be provided. A die-cast aluminum door-panel composed of aluminum alloy A380 is preferred; alternate materials may be considered. The door-panel must be hinged to the luminaire housing and suitably latched and fastened at the closing end. It must be made to be removed easily. The hinge and fastening devices must be captive parts which will not become disengaged from the door panel.

e. Hardware.

All machine screws, locknuts, pins and set screws necessary to make a firm assembly, and for its secure attachment to the mast arm, must be furnished in place. All hardware must be of stainless steel, zinc plated steel, copper silicon alloy or other non-corrosive metal, and where necessary must be suitably plated to prevent electrolytic action by contact with dissimilar metals.

f. Finish.

The luminaire must have a polyester powder coat with a minimum 2.0 mil thickness. Surface texture and paint quality will be subject to approval. Color must be as specified in the order. A paint chip must be submitted as a sample upon request. The finish must exceed a rating of six per ASTM D1654 after 1000 hours of testing per ASTM B117. The coating must exhibit no greater than 30% reduction of gloss per ASTM D523 after 500 hours of QUV testing at ASTM G154 Cycle 6.

g. Ingress Protection.

i. The luminaire electric compartment housing must have an ingress protection rating of IP54 or better as described in ANSI C136.25-2013). The optical system must have a minimum rating of IP 66.

ii. The luminaire must be listed for wet locations by a U.S. Occupational Safety Health Administration (OSHA) Nationally Recognized Laboratory (NRTL) and have a safety certification and file number indicating compliance with UL 1598.

h. General Luminaire Requirements

i. The luminaire must be rated to operate between -40° to +50° Celsius.

ii. The luminaire must have the option of adding a house side shield. The shield should be designed to be easily installed in the field. The house side shield must be composed of a sturdy material capable of withstanding vibrations and weather conditions. The shield must cut off light trespass at approximately one mounting height behind the pole.

iii. The luminaire must meet the requirements of ANSI C136.22 for internal labeling. A bar code with pertinent information for warranty and maintenance must be attached to the inside of the housing. A separate bar code label must be on the driver

The luminaire must be able to provide pertinent product information, for warranty and maintenance purposes, in a digital format that is compliant with the 0-10 VDC Node as per Section III-I-h) . This information will Electrical

iv. be transmitted through the networked Lighting Management control system.

i. Electrical Components

i. LED Optical Arrays

1. The LED arrays must be properly secured at the factory and must not require field adjustment for optimum photometric performance.

ii. Terminal Block

1. A terminal block of high grade molded plastic of the barrier or safety type must be mounted within the housing in a readily accessible location.

2. Terminal block wiring; all necessary terminals, pre-wired to all luminaire components, must be provided.

3. Terminal block terminals must have copper plated or brass plated, clamp-type pressure connectors of an approved type for "line" connections, to accommodate wire sizes from #12 to #8 A.W.G.

4. Terminal block terminals for internal component connections must be either the screw-clamp or quick disconnect type.

iii. LED Driver:

1. Voltage. The electronic driver must operate at an input voltage range of between 120 and 277 volts, 60 Hertz. It must automatically sense the input voltage and adjust the output accordingly. The City uses nominal input voltages of 120, 208, and 240 for street lighting. When operated at any supply voltage between 80 percent and 110 percent of its rated supply voltage and at rated input frequency, a driver shall provide current and/or voltage regulation that equals or exceeds the values specified by the manufacturer.

2. Electrical Safety. Luminaires must operate at or below the Low-Risk Level, as defined in Figure 18 of IEEE 1789-2015. This requirement must be satisfied across the dimming range.

3. Power Factor (PF). The power factor of the driver over the design range of input voltages specified above must be in accordance to ANSI C82.77-2014. PF must be ≥ 0.9.

4. Total Harmonic Distortion (THD). The driver input current must have specified THD in accordance to ANSI C82.77-2014. THD must be $\leq 20\%$.

5. Thermal Protection. The driver must be thermally protected to shut off when operating temperatures reach unacceptable levels.

Electromagnetic Interference. Luminaire must comply with the FCC radiation

6. emission limits for Class B digital devices given at 47 CFR 15.109.

7. Electrical Transient Immunity.

- Dielectric Withstand Testing - luminaire must meet the performance requirements specified in ANSI C136.2-2015 for dielectric withstand, using the DC test level and configuration.

- Electrical Transient Immunity - luminaire must meet the performance requirements specified in ANSI C136.2-2015 for electrical transient immunity, using the Enhanced (10 kV / 5 kA) combination wave test level.

- Transient Immunity Testing Requirements

  - During electrical transient immunity testing, the device under test (DUT) must: be connected to the power source through a series coupler/decoupler network (CDN), using a two-wire (hot or hot/neutral) connection between both the power supply and CDN input and the CDN output and DUT.

  - If AC mains is used to power the DUT, the input waveform must be characterized and documented both before and after electrical transient immunity testing, with the DUT operating at rated full output.

  - For Pre-Test DUT Characterization, the diagnostic measurements shall, at a minimum, include the following: real power, input current (RMS; Root-Means-Square), power factor, and current distortion factor (THD-I Total Harmonic Distortion) when operating at rated full output.

  - Manufacturer must indicate on submittal form whether failure of the electrical transient immunity system can possibly result in disconnect of power to luminaire.

8. Dimming Capability. The driver must be capable of dimming. The dimming range must be 10% to 100% of full output. The digital lighting interface used for dimming must be 0-10 VDC as per the requirements of ANSI C136.41-2013. There must be a minimum of 100 dimming steps between the top and bottom of the dimming range.

iv. Wiring.

All components must be completely factory wired with non-fading, color coded leads. These leads must be insulated with an approved class of insulation and must

1. be #16 AWG conductor at a minimum.
2. All wires within a single circuit path must be of the same size.
3. No wire-nut splicing will be allowed.
4. No unnecessary splices will be allowed.
5. Quick disconnects must be provided for all components.
6. All wires must be properly terminated.

v. Control Device Receptacle and Cap.

1. Twist-lock Receptacle for a control device that meets ANSI C136.41 must be mounted in the top of the housing with provision for proper positioning of the control device.
2. 5-pin Receptacle. The luminaire control receptacle must be fully prewired and compliant with ANSI C136.41-2013.
3. 3-prong Shorting Cap that meets ANSI C136.10 must be provided.
4. Receptacle Wire Leads must all be properly terminated.
5. Receptacle repositioning. The receptacle must be able to be repositioned without the use of tools.
6. Control Devices Not Included in LED Specifications. Whereas specifications for control receptacles are included, specifications for control devices are not. The control device performance requirements are part of the lighting management system specifications in the Smart Lighting Project Technology specifications.

vi. Component Mounting.

All electrical components must be securely mounted in such manner that individual components can be easily maintained or replaced. Permanent straps or tie-wraps will not be permitted. The entire assembly should be easily disconnected and removed for replacement.

(iv) PHOTOMETRIC REQUIREMENTS

i. Light Pollution.

To limit light pollution, the submitted luminaires must not emit any light above the horizon (0 lumens at angles ≥ 90° from luminaire nadir).

ii. Lumen Maintenance.

1. LED arrays must deliver a minimum of 90% of initial lumen output at 36,000 hours of operation.

Light Loss Factor (LLF) < 1.0. Calculations for maintained values, i.e. LLF = LLD x LDD x

2. LAT.

   a. Lamp Lumen Depreciation (LLD) calculated at 60,000 hours as per Section II-B-3-d above,

   b. Luminaire Dirt Depreciation (LDD) ≤0.90, and

   c. Luminaire Ambient Temperature (LAT) ≤0.96

Luminaires with less than 10,000 hours of available LM-80 test data may be submitted for consideration but must be clearly indicated as such.

iii. Color Attributes

1. Color Rendering Index (CRI) shall be no less than 65.

2. Nominal Correlated Color Temperature (CCT) shall be 3000K as defined by ANSI C78.377 and described below:

Manufacturer-Rated Nominal CCT (K)	Allowable IES LM-79 Chromaticity Values	
	Measured CCT (K)	Measured Duv
3000	2870 to 3220	-0.006 to 0.006

iv. City of Chicago Typical Lighting Contexts

ATTACHMENT A (below) lists the photometric performance requirements for luminaires used in the following typical municipal outdoor lighting applications:

- Alleys.
- Modern Residential Streets - staggered poles on both sides.
- Legacy Residential Streets - one-sided pole spacing.
- Legacy Residential Intersections and Alley Entrances.
- Arterial Streets – two-sided opposite pole spacing
- Arterial Streets – two-sided staggered pole spacing
- Arterial Streets – one-side pole spacing

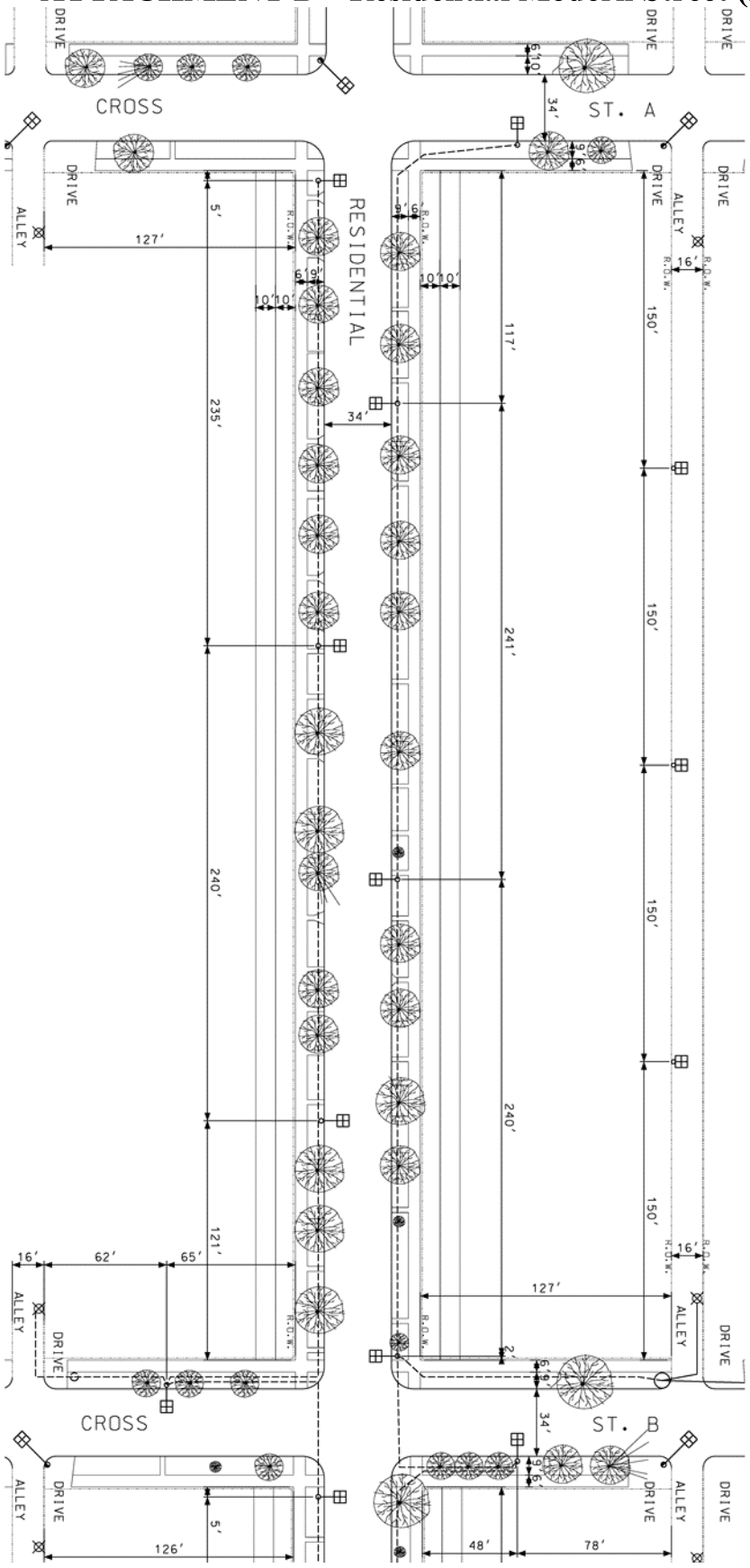
See ATTACHMENTS B, C, & C-1 for residential street layouts.
Note: The layout for (i) the intersection of two Legacy Residential Streets, (ii) an alley entrance intersecting with a Legacy Residential Street, and (iii) a typical alley layout is found in ATTACHMENT C-1. Luminaires for both alley entrance lighting and intersection lighting are oriented 45° from the curb line. All other luminaires are oriented 90° from (i.e., perpendicular to) the curb line.
See ATTACHMENTS D, E, & F for arterial layouts.

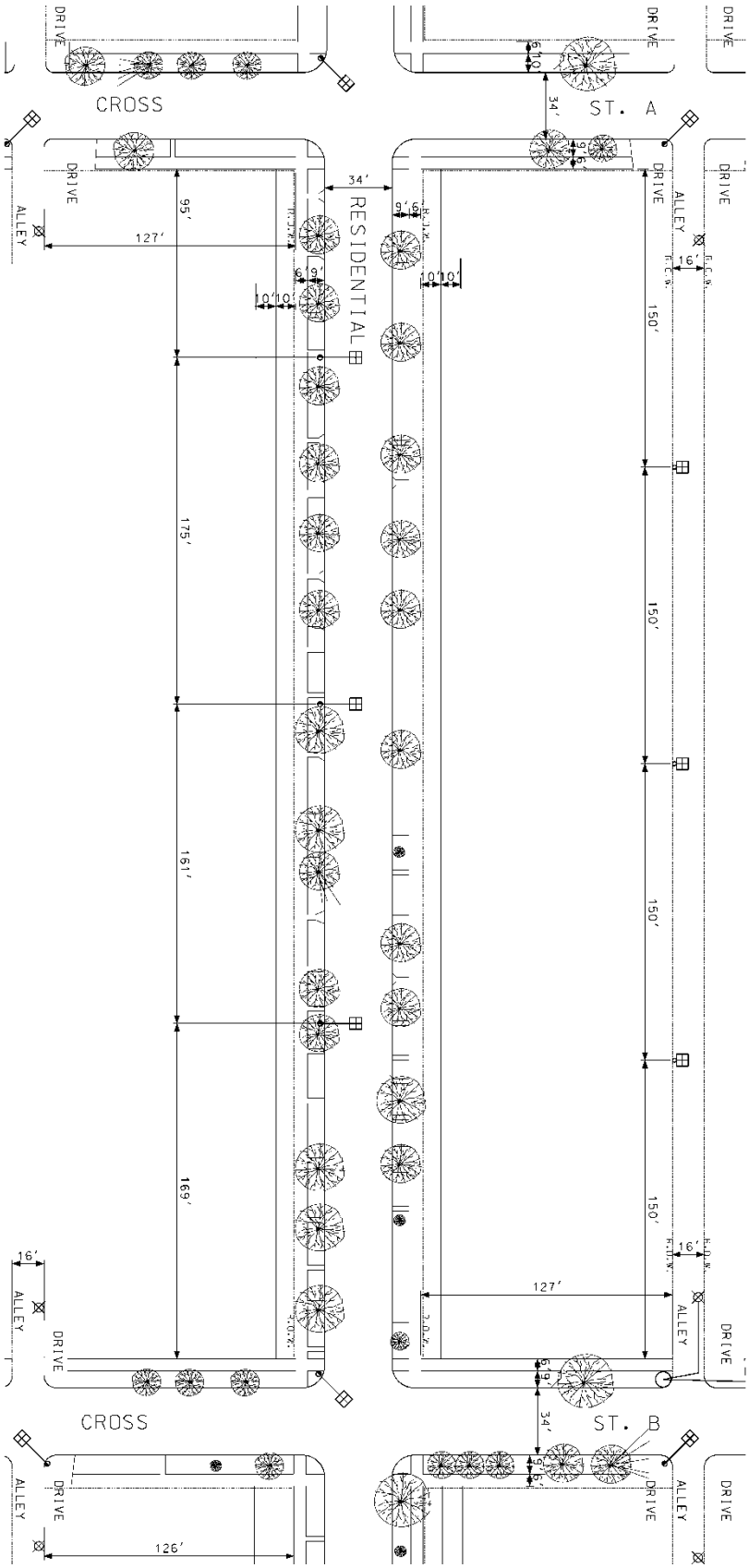
ATTACHMENT A – Photometric Performance Requirements

STREET PARAMETERS							
TYPICAL LIGHTING CONTEXT	**RESIDENTIAL***			**ALLEY**	**ARTERIAL**		
POLE CONFIGURATION*	STAGGERED	ONE-SIDED	INT R-R and R-A	ONE-SIDED	OPPOSITE	STAGGERED	ONE-SIDED
RIGHT OF WAY (Width)	66 ft.	66 ft.	66 ft.	16 ft.	100 ft.	80 ft.	66 ft.
IES PAVEMENT CLASS	R3	R3	R3	R3	R3	R3	R3
STREET WIDTH (Curb to Curb)	34 ft.	34 ft.	34 ft.	16 ft.	80 ft.	60 ft.	48 ft.
LANES (Incl Prking &Median)	4	4	4	2	7	6	4
PARKWAY (Width)	10 ft.	10 ft.	10 ft.	N/A	4 ft.	4’	N/A
SIDEWALK (Width)	6 ft.	6 ft.	6 ft.	N/A	6 ft.	6 ft.	9 ft.
HEIGHT TO LUMINAIRE	18 ft.	22 ft.	22 ft.	18 ft.	33 ft.	33 ft.	33 ft.
MAST ARM LENGTH	8 ft.	15 ft.	15 ft.	1 ft.	12 ft.	12 ft.	8 ft.
POLE SETBACK (From Curb to Center of Pole)	3 ft.	2 ft.	2 ft.	N/A	3 ft.	3 ft.	3 ft.
IN-LINE POLE SPACING	See Site Plan Attachments B thru F for pole spacing assumptions for each Pole Configuration context						
MAINTAINED PERFORMANCE REQUIREMENTS							
LUMINAIRE REQUIREMENTS	STAGGERED	ONE-SIDED	INT R-R and R-A	ONE-SIDED	OPPOSITE	STAGGERED	ONE-SIDED
Max Input Power - Default /Normal Luminance (Watts)	120	130	130	80	180	180	180
Default/Normal AVG. Luminance (cd/m²)	≥1.5	≥1.5	≥1.5	≥.95	≥1.7	≥1.7	≥1.7
AVG/MIN Uniformity Ratio	≤ 6:1	≤ 6:1	≤ 6:1	≤ 6:1	≤ 3:1	≤ 3:1	≤ 3:1
MAX/MIN Uniformity Ratio	≤10:1	≤10:1	≤10:1	≤ 10:1	≤ 5:1	≤ 5:1	≤ 5:1
MAX Veiling Luminance Ratio	≤ 0.4	≤ 0.4	≤ 0.4	≤ 0.4	≤ 0.3	≤ 0.3	≤ 0.3
AVG. Boosted Luminance (cd/m²) [Add-Alternate]	≥2.25	≥2.25	≥2.25	≥1.5	≥2.5	≥2.5	≥2.5
SIDEWALK							
Default AVG. Horizontal Illuminance (fc)	≥0.50	≥0.50	≥0.50	N/A	≥0.50	≥0.50	≥0.50
AVG.MIN Uniformity Ratio (Horizontal Illuminance)	≤ 4:1	≤ 4:1	≤ 4:1	N/A	≤ 4:1	≤ 4:1	≤ 4:1
LIGHT TRESPASS LIMITS - (as measured in a vertical plane 20' beyond ROW ≤3' height)							
Vertical Illuminance **	0.1≤X≤0.5	0.1≤X≤0.5	≤0.30	0.05≤X≤0.5	≤0.30	0.1≤X≤0.5	0.1≤X≤0.5

*Residential Pole Configuration Contexts: See Attachments B, C, & C-1
Staggered = Residential street with Modern poles; (aluminum davit poles staggered on both sides of street) Attachment B.
One-Sided = Residential street with Legacy poles; (steel poles on one side of street) Attachment C
INT R-R = intersection of two Legacy residential streets, illuminated by one luminaire oriented diagonally (45°), Attachment C-1.
INT R-A = intersection of Legacy residential street with alley, illuminated by one luminaire oriented diagonally (45°), Attachment C-1.
**Trespass Limits for the following contexts: Residential Legacy One sided, Alley, Arterial Staggered & Arterial One-sided

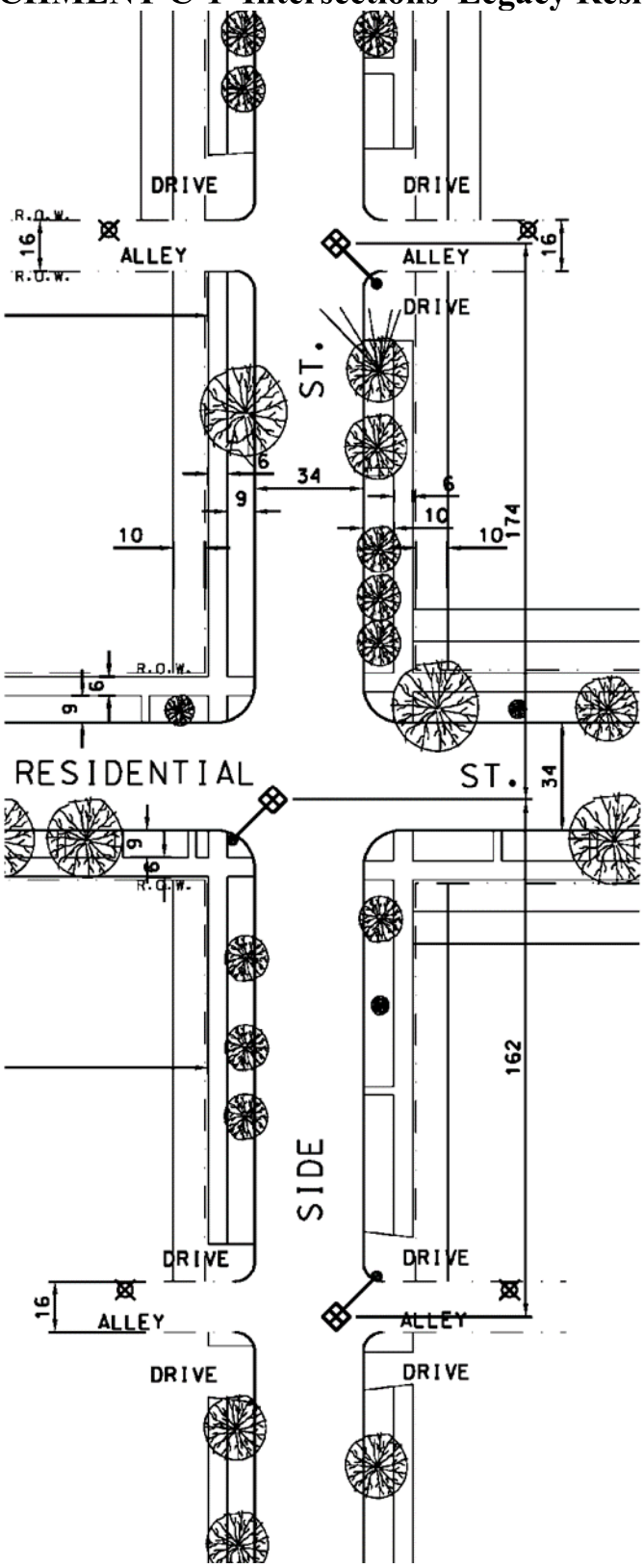
ATTACHMENT B – Residential Modern Street (Staggered) & Alley



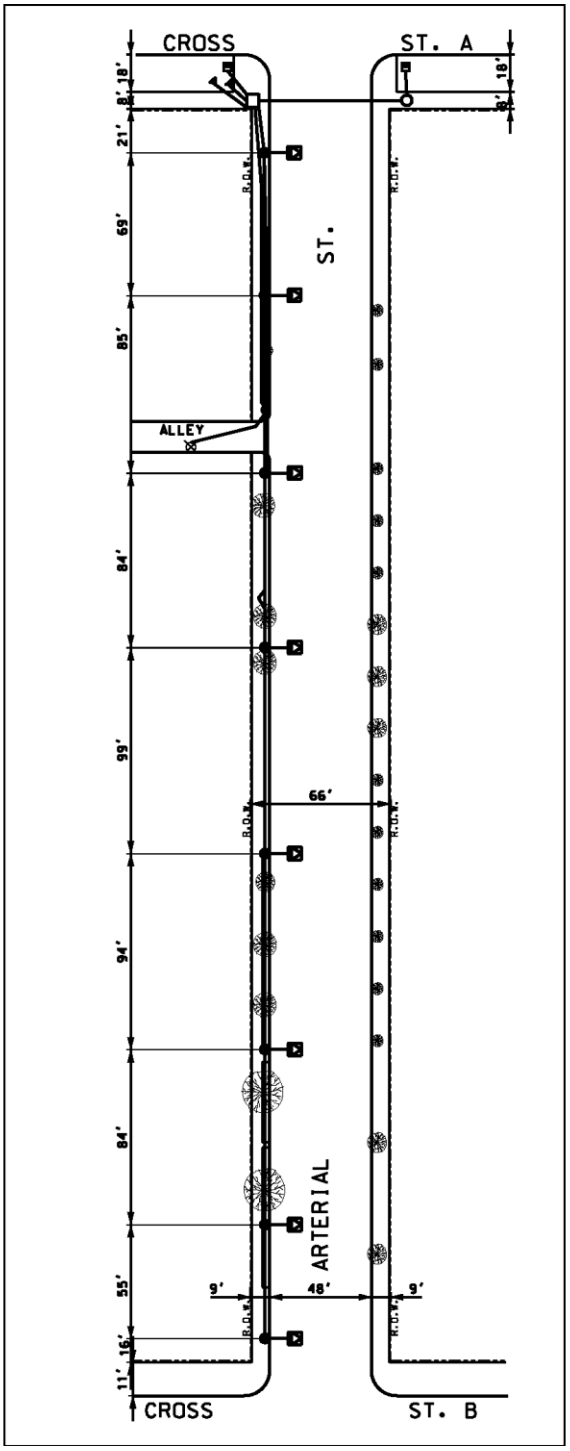


ATTACHMENT C – Residential Legacy Street (One-sided) & Alley

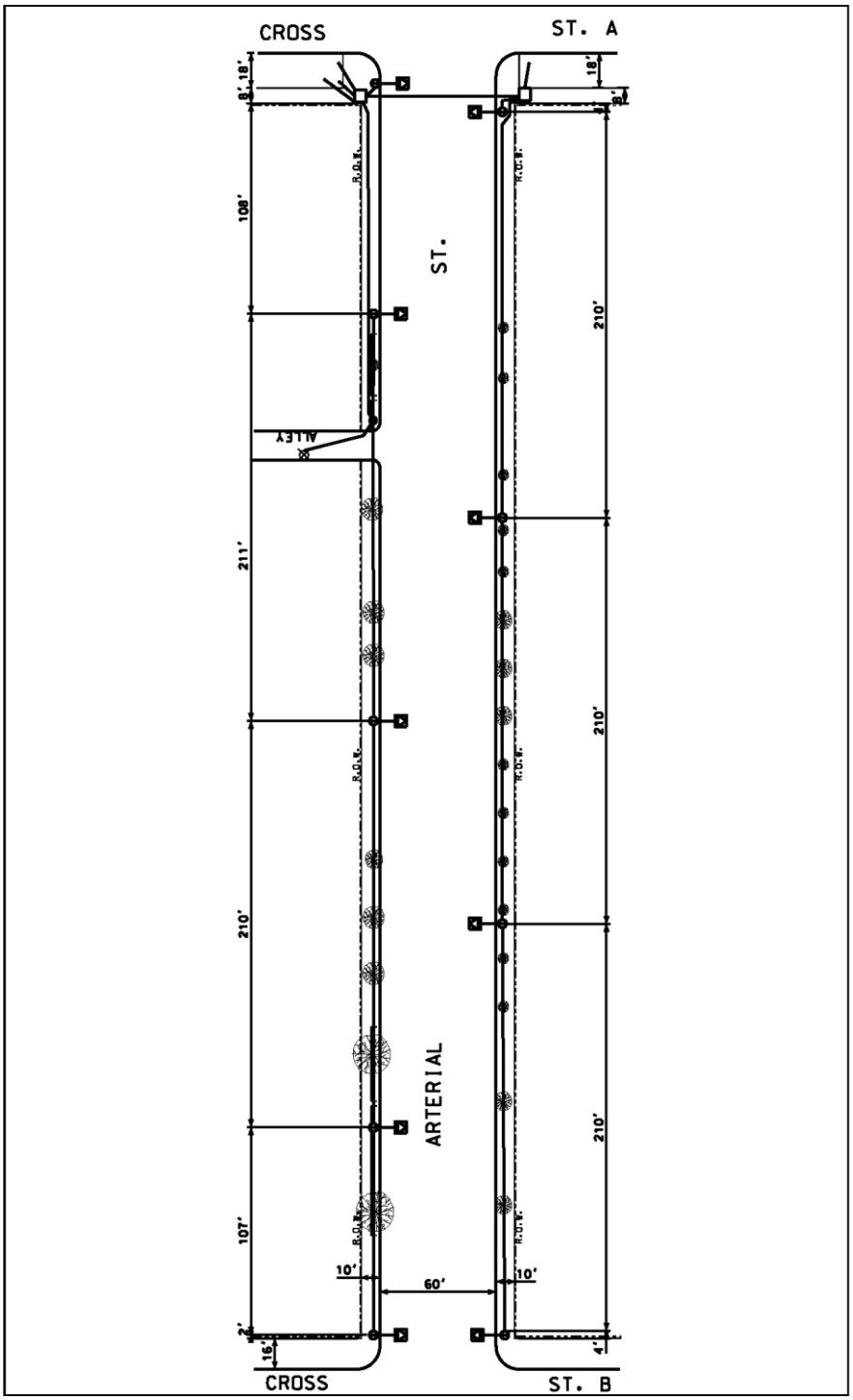
ATTACHMENT C-1–Intersections–Legacy Residential Streets & Alley



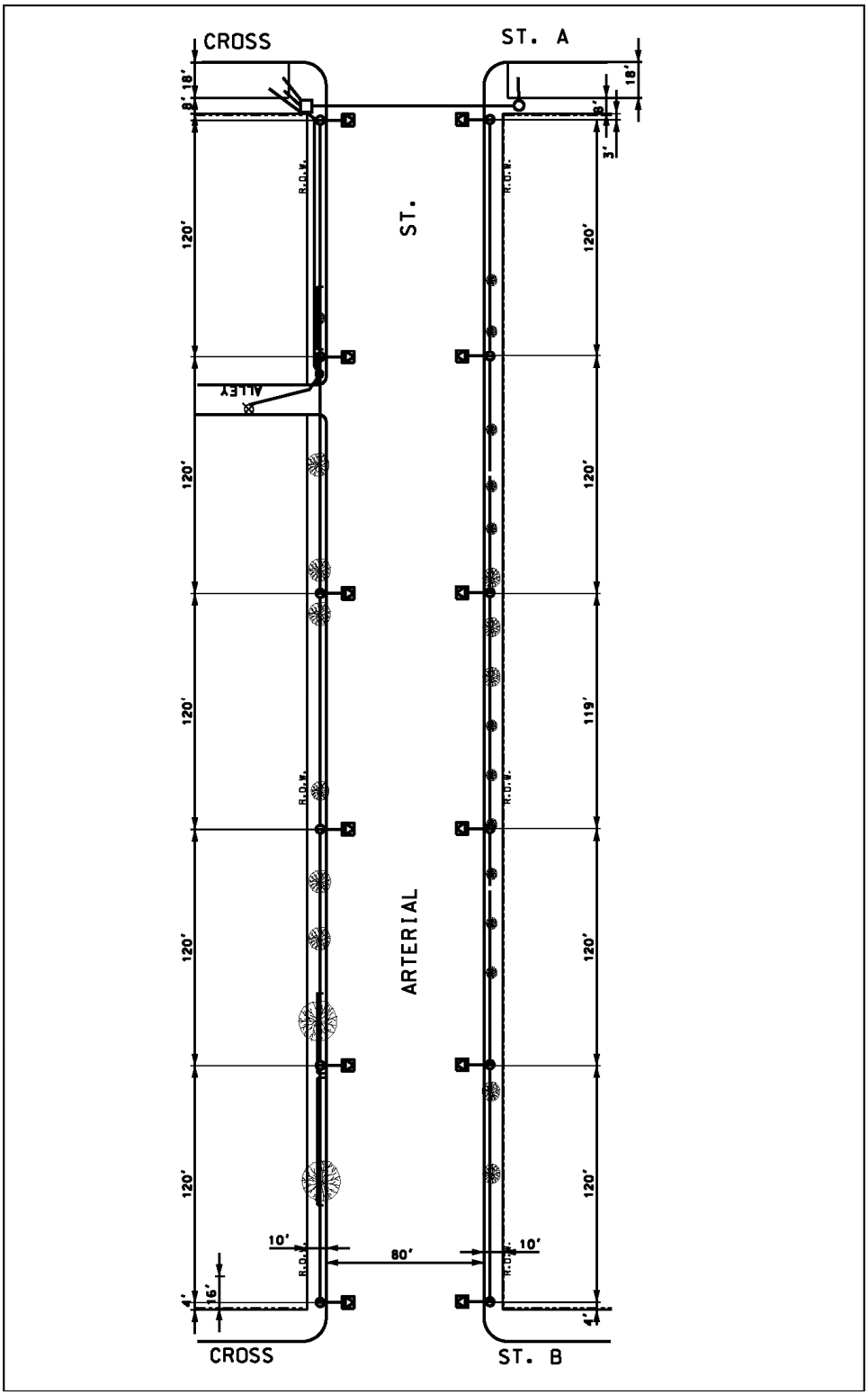
ATTACHMENT D – Arterial Street Single-Sided Poles



ATTACHMENT E – Arterial Street - Staggered Poles



ATTACHMENT F – Arterial Street Opposite Poles



ATTACHMENT G - Product Submittal Form

Lighting Context	**e.g. Alleys**			
Product Information Description	***Product Data (Summary)***			***Submittal Reference Document***
Luminaire Designation				
Luminaire Manufacturer				
Luminaire Model Number				
Luminous Flux – initial			lumens	
Luminaire input power—initial			watts	
Luminaire input power—maintained			watts	
Luminaire input voltage- nominal range			volts	
LED drive current - initial			milliamps	
LED drive current - maintained			milliamps	
CCT (correlated color temperature)			kelvin	
CRI (color rendering index)				
EPA (effective projected area) - nominal			sq. ft.	
Luminaire Weight - nominal			lbs.	
Control Interface			☐ ANSI C136.41, 7-pin	
LED Driver – dimming capability			☐ Dimmable, 0-10 VDC	
LED driver- rated life			years	
Electrical transient immunity ANSI C136.2 combination wave test level	☐ Basic (6kV/3kA)	☐ Enhanced (10kV / 5kA)	☐ Elevated (20kV/10kA)	
Vibration Test-ANSI C136.31			☐ Level 2	
Luminaire warranty period			years	
IES LM-80 test duration			hours	IES LM-80-15 report
LED lumen maintenance at 36,000 hours			%	TM-21 calculator
Max. LED case temperature			degrees Celsius	ISTMT report

APPENDIX B

CDOT SPECIAL PROVISIONS

APPENDIX B

CITY OF CHICAGO
DEPARTMENT OF TRANSPORTATION
STANDARD SPECIFICATIONS

SPECIFICATION NAME

Substitution of Warm Mix Asphalt for Hot Mix Asphalt
Paving Special Provision for WMA/HMA/SMA Materials
Jointing P.C. Concrete Pavement and P.C. Concrete Base
Operation of Traffic Signals
Traffic Signal Turn-On

Substitution of Warm Mix Asphalt for Hot Mix Asphalt (CDOT)

Effective: April 1, 2015
Revised: March 1, 2016

Description. Work under this item shall consist of designing, producing and placing Warm Mix Asphalt (WMA) in lieu of Hot Mix Asphalt (HMA). Work shall be performed according to sections 406, 1030, and 1102 of the Standard Specifications for Road and Bridge Construction and the IDOT Warm Mix Asphalt (BDE) except as herein modified.

General Requirements. The use of WMA technology shall be required for placements occurring between November 1 and May 1.

Equipment. The use of a foaming technology shall not be allowed. Warm Mix Asphalt additives shall be incorporated at the plant and according to Article 1102.01(a)(10) of the Standard Specifications.

Mix Design. Contractor shall perform a verification of their existing approved mix design with the warm mix additive incorporated at the manufacturers recommended dosage. The verification testing, at optimum AC, shall be comprised of one G_{mb} and one G_{mm} sample. The voids shall be within 0.5% of the design value. A Hamburg test (AASHTO T 324) will be required and shall be in accordance with the "HMA Mix Design Requirements (D-1)" Special Provision. One wheel shall be required; an average is acceptable. The volumetric and Hamburg results shall be submitted to the Commissioner for approval. The Commissioner reserves the right to perform their own verification testing using blended aggregate supplied by the contractor.

Construction Requirements.

Add the following paragraph to Article 1030.06(a) of the Standard Specifications:

"If a test strip has already been performed and approved on the design, used as HMA, then a new test strip shall not be required on the design used as WMA. If a nuclear correlation was performed and approved on the design, used as HMA, a new correlation shall not be required on the design used as WMA unless the Commissioner determines a new correlation is necessary."

Basis of Payment.

All costs associated with this special provision shall be considered incidental to the contract unit price of the HMA mixes involved.

PAVING SPECIAL PROVISION FOR WMA/HMA/SMA MATERIALS

Effective: April 1, 2016

Description. Work under this item shall consist of all construction activities associated with the milling and paving of Warm Mix Asphalt (WMA)/Hot Mix Asphalt (HMA)/Stone Matrix Asphalt (SMA) materials. Work shall be performed according to the IDOT Standard Specifications for Road and Bridge Construction (SSRBC), except as herein modified. This Special Provision addresses the proper techniques for longitudinal joint construction, compaction, segregation control, mixture transportation, smoothness, and tack coat preparation and application.

General Requirements. Must meet equipment requirements for Illinois Department of Transportation Prequalification in Work Category 3 – Hot Mix Asphalt (HMA) Plant Mix, requiring an approved HMA plant, an approved HMA spreading and finishing machine and compaction equipment.

Construction Requirements.

Article 406.05(a) Preparation. Insert the following paragraph after the third paragraph.

> "All loose material shall be removed from the surface to be paved. Any material not well adhered to the underlying strata shall be removed prior to application of tack coat."

Article 406.05(b)(1) Tack Coat for Brick, Concrete or HMA Bases. Replace the first sentence with the following:

> "The pavement shall be cleaned to the engineer's satisfaction and free of dirt, dust, debris, organic matter, and other deleterious materials prior to application of tack coat. The contractor shall notify the Engineer that the pavement is ready for inspection prior to tack coat application. The contractor shall provide sufficient notice to the Engineer to allow for inspection and testing at the Engineer's discretion."

Article 406.05(b) Tack or Prime Coat. Delete the first sentence of the second paragraph and replace it with the following:

> "Residual asphalt rate shall be tested sufficiently to ensure proper application. For CDOT projects, the minimum frequency of testing shall be one test per lift for every 5,000 Tons placed, or every 5th paving day, whichever occurs first. If failing results are encountered, each application shall be tested until passing results are found. Payment deduction will be enforced for all pavement affected by failing results. A failing test applies to all areas from the beginning of the job or the most recent passing result. Payment for areas with less than required tack coat shall be:
>
> % Payment = (Tack Coat Applied)/(Tack Coat Required) X 100%

The reduction will be applied to the payment for the HMA lift immediately above the insufficient tack coat."

Article 406.06(e) Spreading and Finishing. Insert the following paragraphs after the second sentence in the last paragraph:

"The stringline shall be painted on the pavement or base in a manner that provides a clear, well defined path for the paver operator to follow. The paver operator shall operate the paver in such a manner that the stringline guide is clearly visible. The stringline shall be used for every lift. Additional care must be taken where curved streets are being paved to ensure a good guideline through the curves.

All paving shall be performed with an operating vibratory screed. The vibrator must be functional for the entire width of the screed and shall be active during all paving.

The use of the grade reference device is required for all mainline pavement. Any pavement obstructions which restrict its use must be reported to the Engineer immediately.

The paver screed shall be operated such that the end gate shoe is in contact with or within ½" of the pavement surface while paving to properly form the pavement edge and minimize the need for raking at the joints."

Article 406.06(f) Segregation Control. Insert the following paragraph after the third paragraph:

"The Engineer will inspect the pavement for evidence of segregated mix producing "fat" spots. "Fat" spots are defined as localized areas of high AC content and may appear to the eye as small areas of flushing. For any HMA lift, a 1 ton deduction in quantity will be applied for each fat spot exceeding 1' x 1'. Removal and replacement may be required by the Engineer in the case of excessively large areas.

CDOT HMA Workmanship Inspection forms will document fat spots and other forms of segregation and will be required for payment and project close-out."

Article 406.06(g)(1) Transverse Joints. Insert the following sentence after the last paragraph:

"A transverse construction joint shall be established any time the paving operation is halted for 20 minutes or more."

Article 406.06(g)(2) Construction Joints. Insert the following paragraph after the last

paragraph:

"The contractor shall continuously monitor the constructed longitudinal joints for straightness. Using the 16' rolling straight edge (required to be provided by the contractor per Article 406.11), the Engineer will assess a 1 ton quantity deduction for each instance where a 2" or greater deviation in the longitudinal joint is found within the length of the straightedge. No more than 1 deduction will be assessed in any 16' length. Joint straightness deductions will be reported as part of the CDOT Daily HMA Workmanship Inspection form and are required for payments and for project close-out."

Article 406.07(a) Rollers. Revise Table 1 note /3 to read:

"A vibratory roller (V_D) may be used in lieu of the pneumatic-tired roller."

Article 406.07(c) Density. Insert the following paragraph after the first paragraph:

"All cores for acceptance of HMA shall be cut within 24 hours of paving and all test results shall be transmitted to the Engineer with 24 hours of coring. No further paving shall be permitted until all results are submitted to the Engineer."

Article 406.11 Surface Tests. Revise the second sentence of the first paragraph to read:

"Surface variations of the mainline pavement shall not exceed 3/8 in. (5 mm)."

Article 406.11 Surface Tests. Insert the following paragraph after the last paragraph:

"The Engineer will test smoothness daily, preferably during paving to allow for the possibility of rolling out some defects and minimize the need for additional traffic control. Each paved lane will be tested, at a minimum in the wheel path closest to the centerline of the roadway. The Engineer may, at their discretion, allow exclusion of penalty in areas extending 10' from the radius of a street return and 5' from an embedded drainage or utility structure, as well as test sections. All smoothness inspection shall be reported on the CDOT Daily HMA Workmanship Inspection form and are required for payments and for project close-out."

Article 1030.05(d)(3) Required Field Tests. Add the following sentence to the end of the second paragraph:

"The lowest acceptable R-squared for a correlation in the Standard Test Method for Correlating Nuclear Gauge Densities shall be 0.87."

Article 1030.08 Transportation. Insert the following paragraph after the first paragraph:

"Diesel shall be prohibited from use as a cleaner or release agent on the box, gate, pan and other areas of HMA contact. The detection of diesel in these areas is grounds for rejection of the load, even if it has already been dumped into the hopper of the paver. Trucks rejected from the job site will not be allowed back on CDOT projects until inspected and accepted by the Engineer."

Article 1030.08 Transportation. Insert the following paragraph after the last paragraph:

"Trucks with tarps that do not fully cover the truck bed shall be prohibited from the project. All trucks shall be equipped with a suitable spread pan to allow the HMA to be dumped into the paver hopper with minimal spillage."

Article 1101.01(g) Rollers. Add to the last paragraph the following:

"The Engineer will confirm the recommended frequency and amplitude have been verified daily by QC with a reed tachometer and properly documented on the appropriate QC forms and density reports."

CITY OF CHICAGO
BUREAU OF STREETS
SPECIAL PROVISION
FOR

JOINTING P.C. CONCRETE PAVEMENT AND P.C. CONCRETE BASE

EFFECTIVE MAY 1, 1981

TRANSVERSE JOINTS. The number and (or) locations of new and existing structures vary in practically every street block of similar length, width and configuration within a project. Although each block must be dealt with individually, the appearance of the general transverse joining scheme and the treatment of structures is to be as uniform as possible for the entire project.

After all structure castings have been adjusted to the finished pavement grade and the concrete pavement has been poured, transverse contraction joints must be cut or formed in the pavement using acceptable methods and at a time specified by the Engineer.

The primary transverse contraction joints must be located in line with the center of (1) designated city sewer manhole structure castings, and (2) city seer catch basin structure castings that are transversely opposite to each other. The transverse joints established at these city sewer structures and the expansion joints that define the street intersections must be control joints. However, at no time may these control joints be closer than 10' to one another. If this occurs, in one case, due to the proximity of two existing structure castings to one another, one structure casting must be designated for the control joint and other structure casting must be isolated. In the other case, when a structure casing (e.g., Sewer Manhole) is less than 10' from and expansion joint, the structure casting must be isolated.

All other transverse joints must be divided between control joints and have a maximum spacing interval of 20'. The minimum allowable distance between transverse joints must be 10'.

STRUCTURE ISOLATION. The isolation of structures (Catch basins, Manholes, City and Public Utility Vaults, etc.) will be permitted only when necessary as based on criteria contained herein and then only at the direction of the Commissioner. The side(s) of any necessary isolation box(es) will be made part of the transverse and/or longitudinal joining scheme when possible and practical.

TREATMENT OF STRUCTURES AND TRANSVERSE JOINT LOCATION ADJUSTMENT.

Following are various conditions that will be encountered and procedures to be used for construction:

Structure Castings (e.g., Sewer Manhole) Intersected by Longitudinal Joints.

When a longitudinal joint either bisects a structure casting or intersects within 6" of the center of the casting, do not isolate the structure.

In the above case where the structure casting is not bisected, the longitudinal joint must start deviating from its normal position at the intersection with the nearest transverse joints on either side of the structure and must then extend as a straight line to the center of the structure casting.

When a longitudinal joint intersects a structure casting but neither bisects it, nor intersects within 6 inches of its center, the structure must be isolated.

If it is a control structure (e.g., Sewer Manhole) the position of the transverse control joint that normally bisects it must be adjusted longitudinally to form one of the standard structure isolation box. This transverse control joint must be located 12" from the upper external casting edge in the direction that provides joint spacing between the next immediate control points that meet criteria set forth earlier.

Structure Casting (e.g., Sewer Manhole) that must be isolated and is Transversely Opposite a Pair of Catch basins.

When a sewer manhole structure transversely opposite a pair of catch basins must be isolated, the position of the catch basins is to be adjusted longitudinally so that the transverse control that bisects them will form a side of the standard structure isolation box.

When there is latitude in the drainage design scheme that permits the choice of adjusting the position of this transverse control joint 12" to either side of the upper external casting edge, the movement must be in the direction that provides joint spacing between the next immediate control joints that meets criteria set forth earlier.

Structure Casting Within a Panel.

When any joint on any external casing edge is not closer than 12" but no further than 18" from a joint (longitudinal and/or transverse) the structure is to be isolated and the transverse and/or longitudinal joint is to form a side of the standard isolation box.

When a longitudinal joint does not intersect any part of the structure casting but the distance between said joint and the upper external casting edge is less than 12", one of the following treatments is to be selected based on the various controlling criteria and conditions:

Do not isolate. Adjust the position of the transverse joint longitudinally to bisect structure casting. Adjust panel spacing between control joint that meets criteria set forth earlier.

Isolate structure casing and adjust the position of the transverse joint longitudinally to form a side of the Standard Isolation Box. The movement must be in the direction that provides joint spacing between the next immediate control joints that meets criteria set firth earlier.

Isolate structure according to the Standard Details without adjusting transverse joint location.

When the upper external casting edge is over 18" from any joint, either transverse or longitudinal, the structure must not be isolated but the concrete is to be placed against and

around the structure casting.

When a structure must be isolated and the distance between the side of the Standard Isolation Box and an immovable joint is 18” or less, extend the adjacent sides of the box to intersect said joint making it a side of the box. If this distance is more than 18” isolate the structure according to the Standard Detail for Isolation of Structure Castings.

Structure Casting Isolation in Gutter Line.

When a structure casting (e.g., Sewer Catch basin) in the gutter line must be isolated, and it is a control structure, the transverse joint at this location is to form one side of the isolation box. If the location of the catch basin can be adjusted longitudinally, it must be moved in the direction that provides the most advantageous position to any structures or isolation boxes opposite it in pavement and optimum joint spacing between the next immediate control points.

OPERATION OF TRAFFIC SIGNALS

Existing traffic control signal installations and/or any electrical facilities at certain intersections included in this section may be altered or reconstructed totally or partially as part of the work on this section. The Contractor is hereby advised that all traffic control equipment presently installed at these locations may be the property of the City of Chicago.

The Contractor is further advised that the existing traffic signals, or the existing temporary installation, must remain in operation during all construction stages except for the most essential down time. Any shutdown of the installation for a period exceeding fifteen (15) minutes must have the prior approval of the Commissioner. Such approval will generally only be granted during the period extending from 10:00 A.M. to 3:00 P.M. on weekdays. Any other traffic signal shutdown outside of the 10:00 A.M. to 3:00 P.M. weekday period must have prior approval of the Commissioner.

The Contractor, prior to the commencement of his work must notify the City of Chicago of his intent to perform his work. Upon request from the Contractor, the City of Chicago will locate any buried conduit or other electrical facility which may interfere with the Contractor's operations without charge to him. This will in no way relieve the Contractor's responsibility to repair and/or replace electrical facilities damaged by his operations.

Any known or suspected damage to the electrical facility must be reported immediately to the Commissioner. The Contractor will be held fully responsible for the repair and/or temporary repair if, in sole opinion of the Commissioner, such damage was caused by the negligence of the Contractor, his agents, or employees. The City of Chicago, at its own discretion, may call upon the City of Chicago’s Electrical Maintenance Contractor to make any such repair and/or replacements at the total expense of the Contractor for this Section.

No part of this special provision may be construed as exempting the Contractor from his duty to follow careful construction practices, including all standard provisions in the Standard Specifications.

The intent of this special provision is to prescribe a procedure wherein a Contractor may obtain formal approval of a traffic signal installation at a given intersection, and a release from maintenance responsibility for the new materials installed, in order to be permitted to disconnect and remove the old traffic signal equipment.

When the road is open to traffic, except under conditions where existing traffic signals are being maintained or when a temporary traffic signal installation has been installed, the Contractor may request a turn-on and inspection of the completed traffic signal installation at each separate location. This request must be made to the City of Chicago, a minimum of three (3) working days prior to the time of the requested inspection. Upon demonstration that the signals are operating and all work is completed in accordance with the Contract and to the satisfaction of the Commissioner, the Bureau of Electricity's inspector will then allow the signals to be placed into continuous operation. The Agency that is responsible for the maintenance of each traffic signal installation will assume the maintenance upon successful completion of this inspection.

TRAFFIC SIGNAL TURN-ON

The intent of this Special Provision is to prescribe a procedure whereby a Contractor may obtain formal approval of a traffic signal installation at a given intersection, and a release from maintenance responsibility for the new materials installed, in order to be permitted to disconnect and remove the old traffic signal equipment.

When the road is open to traffic, except under conditions where existing traffic signals are being maintained or when a temporary traffic signal installation has been installed, the Contractor may request a turn-on and inspection of the completed traffic signal installation at each separate location. This request must be made to the City of Chicago, a minimum of three (3) working days prior to the time of the requested inspection. Upon demonstration that the signals are operating and all work is completed in accordance with the Contract and to the satisfaction of the Engineer, the Bureau of Electricity's inspector will then allow the signals to be placed into continuous operation. The Agency that is responsible for the maintenance of each traffic signal installation will assume the maintenance upon successful completion of this inspection.

APPENDIX C

CHICAGO DEPARTMENT OF WATER MANAGEMENT

SELECTED SPECIFICATIONS

CITY OF CHICAGO
Department of Water Management

AS BUILT - RECORD DRAWINGS FORM

The contractor will be required to submit "as-built plans" / record drawings of all new sewers and sewer structures that will be owned and maintained by the City. These "as-built plans" / record drawings should be sealed by a registered land surveyor and/or a registered professional engineer and **submitted within three weeks after the completion of the sewer work.** These "as-built plans" / record drawings should be forwarded to the Department of Water Management, Bureau of Engineering Services, Sewer Design Section located at 1000 East Ohio Street, Elevation +51, Room 313, Chicago, Illinois 60611 along with a copy of this form, the coinciding sewer permit and video tape, as applicable.

Drainlayer's Name: _____ Phone No.:

Drainlayer's Signature:

Date of Project Completion:

Date Submitted As-Built Plan / Record Drawing:

- - - -

APPENDIX C

CITY OF CHICAGO
DEPARTMENT OF WATER MANAGEMENT SPECIFICATIONS
APPENDIX TO SPECIAL PROVISIONS

SECTION NUMBER	SPECIFICATION NAME
01 42 00	References Definitions & Abbreviations
05 10 00	Structural and Miscellaneous Steel
31 23 19	Dewatering Excavations

SECTION 01 42 00

REFERENCES DEFINITIONS & ABBREVIATIONS

PART 1 – GENERAL

1.1 FORM OF SPECIFICATIONS

A. Wherever used in the Specifications, the following terms have the meanings indicated which are applicable to both the singular and plural form of the word.

B. Where "as shown," "as indicated," and "as detailed," or words of similar import are used, it is understood that reference to the Drawings is made unless stated otherwise. Where "as directed," "as permitted," "approved," or words of similar import are used, it is understood that the direction, requirements, permission, approval, or acceptance of the City is intended unless stated otherwise.

1.2 DEFINITIONS

A. Addenda: Written or graphic instruments issued prior to the opening of bids, which clarify, modify, or interpret the Contract Documents.

B. Agreement: The written Contract, which is evidence of the agreement between the City and the Contractor covering the Work.

C. Arterial Streets: Major streets where special construction techniques may be

required by CDOT.

D. Chief Procurement Officer: The Chief Procurement Officer of the City of Chicago.

E. City: The City of Chicago.

F. Water Management or the Commissioner's duly authorized representative.

G. Completion: All tests performed and accepted, water services transferred, connections made, and abandonment's completed.

H. Comptroller: The City Comptroller of the City of Chicago or the Comptroller's successor or successors upon whom the Comptroller's duties are transferred.

I. Contract: The entire and integrated written agreement between the City and the Contractor concerning the Work. The Contract supersedes prior negotiations, representations, or agreements, whether written or oral.

J. Contract Documents: The Agreement, Addenda, Contractor's bid, and related documentation when attached as an exhibit to the Agreement, the Notice to Proceed, the Bonds, the General Conditions, the Special Conditions, the Specifications and the Drawings, together with all Written Orders which completely describe the technical requirements of the Project including bid, Contract, and construction procedures.

K. Contract Notice: A written notice from the Chief Procurement Officer mailed to the Contractor at the address designated in the Contractor's proposal or to such other address as the Contractor may designate in writing as Contractor's official place of business, transmitting to the Contractor an executed copy of the Contract.

L. Contractor: The person, firm, or corporation with whom the City has

executed the Contract, and is referred to throughout the Contract Documents as if singular in number and masculine in gender. The term Contractor means the Contractor or his authorized representative.

M. Defective: An adjective which when modifying the word Work refers to Work that is unsatisfactory, faulty, or deficient, in that it does not conform to the Contract Documents, or does not meet the requirements of any inspection, reference standard, test, or approval referred to in the Contract Documents, or has been damaged prior to final acceptance.

N. Department: The City of Chicago Department of Water Management.

O. Drawings or Plans: The part of the Contract Documents, which shows the characteristics, and scope of the work to be performed and which have been prepared and approved by the Engineer.

P. Engineer: The Deputy Commissioner of the Bureau of Water Engineering Services or the Deputy Commissioner's duly authorized representative.

Q. Force Account: The method of payment for extra work performed.

R. Furnish: Furnish means supply and deliver to the Work area, ready for unloading, unpacking, assembly, installation, and similar operations.

S. Install: Install means the actual unloading, packing, assembly, erection, constructing, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations.

T. Municipal Code: The Municipal Code of the City of Chicago.

U. Neat Lines: The required clear width of a trench or excavation. In sheeted trenches, the required width is measured to the outside of the sheeting. Unless noted elsewhere on the Plans, neat line clear width is equal to:

1. The sum of the outside diameter of the pipe plus 2-feet for water main construction,
2. The sum of the outside diameter of the pipe plus 8-feet for sewer construction.
3. The sum of the outside diameter or edge plus 4-feet for structure construction

V. Notice to Bidders: The advertisement for bids, the official notice inviting bids for the work to be done.

W. Product Data: Illustrations, standard schedules, performance charts, instructions, brochures, diagrams, and other information furnished by the Contractor to illustrate a material, product, or system for some portion of the Work.

W. Project: The total construction of which the Work to be provided under the Contract Documents may be the whole, or a part as indicated elsewhere in the Contract Documents.

X. Provide: Furnish and Install as required.

Y. Samples: Physical examples which illustrate materials, equipment, or workmanship and establish standards by which the Work will be judged.

AA. Shop Drawings: All drawings, diagrams, illustrations, brochures, schedules, and other data, which are prepared by the Contractor, Subcontractor, manufacturer, supplier, or distributor, which illustrates how specific portions of the Work are proposed to be fabricated or installed.

BB. Site and/or Work Area: The lands and other places on, under, in, or through which the Work is to be executed or carried out and any other lands or places provided by the City for the purposes of the Contract, together with such other places as may be specifically designated in the Contract Documents as forming part of the Site and/or Work Area.

CC. Specifications: A part of the Contract Documents consisting of written descriptions of a technical nature of materials, equipment, construction systems, standards, and workmanship.

DD. State: The State of Illinois.

EE. Subcontractor: An individual, firm, or corporation having a direct contract with the Contractor or with any other Subcontractor for the performance of a part of the Work at the Site. The term Subcontractor is referred to throughout the Contract Documents as if singular in number and masculine in gender and means a Subcontractor or his authorized

representative.

FF. Supplier: Any person, supplier, or organization who supplies materials or equipment for the Work, including that fabricated to a special design, but who does not perform labor at the Site. A supplier is not a Subcontractorwho purchases an item or equipment from a manufacturer or supplier.

GG. Unit Price: A cost per unit of work or measurement of material, for a bid item.

HH. Work: All labor necessary to produce the construction required by the Contract Documents, and all materials and equipment incorporated or to be incorporated in such construction. Work is also used to mean the same as Project.

II. Written Order: A directive, written and signed by the Commissioner, delivered to the Contractor at the address designated in the Contractor's bid or to such other address as the Contractor may designate in writing as Contractor's official place of business.

1.3 CITATION OF OTHER SPECIFICATIONS

A. Commonly used abbreviations have the meanings as specified in this Section. The plans may contain a list of additional abbreviations applicable thereto. Whenever the Contract Documents refer to the specifications of any society, institute, association, or governing organization, the specifications cited will become a part of this Contract as if written herein in full.

1.4 ABBREVIATIONS

A. AASHTO: American Association of State Highway & Transportation Officials.

B. ACI: American Concrete Institute.

C. AISC: American Institute of Steel Construction.

D. ANSI: American National Standards Institute.

E. APWA: American Public Works Association.

F. ASCE: American Society of Civil Engineers.

G. ASME: American Society of Mechanical Engineers.

H. ASTM: American Society for Testing and Materials.

I. AWS: American Welding Society.

J. AWWA: American Water Works Association.

K. CCD: Chicago City Datum.

L. CDOT: City of Chicago Department of Transportation.

M. CRSI: Concrete Reinforcing Steel Institute.

N. FS: Federal Specification Board.

O. IDOT: Illinois Department of Transportation.

P. IEPA: Illinois Environmental Protection Agency.

Q. ISO: Insurance Services Office of Illinois.

R. MWRD: Metropolitan Water Reclamation District of Greater Chicago.

S. NBFU: National Board of Fire Underwriters.

T. NBS: National Board of Standards.

U. NCMA: National Concrete Masonry Association.

V. NCPWB: National Certified Pipe Welding Bureau.

W. NEMA: National Electric Manufacturers Association.

X. NPT: National Pipe Thread.

Y. OSHA: Occupational Safety and Health Act.

Z. PCA: Portland Cement Association.

AA. SSRBC: Illinois Department of Transportation, Standard Specifications for Road and Bridge Construction.

BB. UL: Underwriters' Laboratory.

PART – 2 – PRODUCTS – (NOT APPLICABLE)

PART - 3 – EXECUTION – (NOT APPLICABLE)

END OF SECTION 01 42 00

SECTION 05 10 00

STRUCTURAL AND MISCELLANEOUS STEEL

PART 1 - GENERAL

1.1 DESCRIPTION. OF WORK

A. This Section includes requirements for structural and miscellaneous steel, including all ferrous metals, whether wrought, rolled, fabricated or assembled, except construction castings (frames, grates, solid lids, & steps), pipe (ductile or steel) and steel plates. The classification includes steel angles and bracing, steel sheet piling, inserts, pins, bolts, nuts, washers, and similar items used for constructing temporary or permanent supports for excavations or work specified in other sections of this specification.

1.2 REFERENCES

A. American Society for Testing and Materials (ASTM), latest edition:

1. AISC Manual of Steel Construction, Volumes I & II.
2. ASTM A36 - Carbon Structural Steel.
3. ASTM A276 - Stainless Steel Bars and Shapes.
4. ASTM A283 - Low and Intermediate Tensile Strength Carbon Steel Plates.
5. ASTM A307 - Carbon Steel Bolts and Studs.
6. ASTM A328 - Steel Sheet Piling.
7. ASTM A572 - High Strength Low Alloy Columbium-Vanadium Structural Steel.

1.3 SUBMITTALS

A. Refer to Book I for submittal requirements and procedures for Shop Drawings, Product Data, Records and Samples.

B. Complete data on date of manufacture dates of initial installation and extraction, and service for used sheet piling, must be furnished to the Commissioner for all sheet piling used in the Work.

PART 2 - PRODUCTS

2.1 STRUCTURAL AND MISCELLANEOUS STEEL

A. Structural and miscellaneous steel must meet the requirements of the following standards, except as specified otherwise:

1. Structural Steel Shapes and Plate - ASTM A36

2. Mild Steel Plate - ASTM A283

3. Standard Bolts - ASTM A307

4. Steel Sheet Piling - ASTM A328, A572 Grades 45, 50 and 55

5. Stainless Steel Anchor - ASTM A276 Bolts Type 304

2.2 BOLTS AND NUTS

A. Bolts and nuts must be of the best quality mild steel, except where bronze, aluminum, stainless steel, or other materials are shown or required.

B. Bolts must have hexagonal nuts.

C. Threads must be clean cut of American Standard size.

2.3 SHEET STEEL PILING

A. All piling must be new or good quality used material approved by the Commissioner.

B. All sheet piling must be true and straight with undamaged interlocks or ends.

C. Used sheet piling must have been driven only one (1) time before being offered for use on this project.

D. Used sheet piling must be made available for inspection by the Commissioner before it is shipped to the job Site.

2.4 ANCHORS

A. Anchors must be designed for rigid fastening to the structures, whether directly or through brackets.

B. The design of all anchors is subject to the approval of the Commissioner.

C. Anchors for piping must be of the cast iron chair type with steel straps, except where anchors form an integral part of pipe fitting, or where an anchor of special design is required.

2.5 INSERTS

A. Inserts must be designed to permit the rods to be adjusted horizontally in one (1) plane and to lock the rod nut or head automatically.

B. Inserts must be recessed near the upper flange to receive reinforcing rods.

C. Inserts must be so designed that they may be held in position during concrete pouring operations.

D. Inserts must be designed to carry safely the maximum load that can be imposed by the rods, which they engage.

E. Inserts for concrete must be galvanized.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. The design, workmanship, and erection must conform to the requirements of the AISC Specifications for Design, Fabrication, and Erection of Structural Steel for Buildings, unless otherwise shown, specified, or required.

B. The Contractor is responsible for the correctness of all shop and field fabrication and fit. Members must be straight, must fit closely together, and the finished work must be free from burrs, twists, bends, and open joints.

C. Where shop assembly of field connections is shown, specified or required, the unmatched holes must be reamed and the pieces match marked before disassembly. No drifting will be allowed.

D. In case the eccentricity is too great for good work or the strength of the joint is liable to be weakened by reaming, the piece will be rejected and a new satisfactory one must be provided at the Contractor. This process is considered incidental to the construction and no additional payment will be allowed.

3.2 FIELD CONNECTIONS

A. Weld or bolt all field connections as hereinafter specified unless riveted connections are approved by the Commissioner.

3.3 WELDING

A. Welding must be performed by qualified welders in accordance with the requirements of the AISC Specifications.

B. In assembling and during welding, the component parts of built-up members must be supported and held by sufficient clamps and other adequate means to hold the parts in proper relations for welding.

3.4 STEEL SHEET PILING

A. Drive steel sheet piling to depth as shown, or as approved by the Commissioner.

B. Drive all sheet piling plumb and tight to the lines and grades shown and as directed.

C. The driven sheet piling must be stiffened horizontally, as necessary to meet the requirements of Section 31 23 10 – Excavation, Trenching and Backfilling.

3.5 NUTS, BOLTS, AND ANCHORS

A. Anchors must be furnished and installed when specified, shown, or required for holding the pipelines and equipment in position or alignment.

B. Set anchor bolts accurately set to maintain elevation and location, and if placed after concrete is cast, all necessary drilling and grouting must be considered incidental to the construction process and no additional payment will be allowed.

C. Coat anchor bolt threads heavily with grease while concreting.

D. Bolt anchors must be of the sizes indicated or approved and must be of the self-drilling type.

E. All anchor bolts and nuts submerged or subject to periodic wetting must be of stainless steel unless shown or specified otherwise.

3.6 INSERTS

A. Install inserts in the concrete structures where required for fastening supporting devices.

END OF SECTION 05 10 00

SECTION 31 23 19

DEWATERING EXCAVATIONS

1.1 DESCRIPTION OF WORK

A. This section includes requirements for dewatering excavations when necessary to provide a safe working environment and protect the Work so as to provide a satisfactory installation.

1.2 WORK OF THIS SECTION SPECIFIED ELSEWHERE

A. Section 01 11 00 – Summary of Work.

1.3 SUBMITTALS

A. Refer to Book I for submittal requirements and procedures for Shop Drawings, Product Data, Records and Samples.

B. Prior to commencing excavation work at the project site, the Contractor must submit to the Commissioner for review and comment a method for removing water which has entered the excavation either from groundwater sources, surface drainage, or other source such as the dewatering of a new or existing water or sewer main. The submittal must include a description of the source of the water, equipment to be used to dewater the excavation, the arrangement and discharge rate of the equipment expressed in gallons per minute. No excavation is to be started until authorization has been given by the Commissioner to proceed with the excavation work.

C. When applicable for sewer projects, the Contractor is to submit the proposed method for by-pass pumping and fluming of sewage to the Commissioner for review and comment.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION 3.1

PREPARATION

A. Capacity of Facilities

1. Facilities for the removal and disposal of water must be of sufficient capacity to keep the excavation dry under all circumstances.

B. Standby Facilities

1. Adequate standby facilities must be provided to insure that the excavation will be kept dry in the event of power failure or mechanical breakdown.

C. Well Points

1. If well points are used, the Contractor must make provisions for removing and resetting individual well points without taking any part of the dewatering system out of service.

3.2 CONSTRUCTION

A. Dewatering

1. At all times during the excavation period and until completion of the Work and acceptance at final inspection, ample means and equipment must be provided with which to promptly remove and properly dispose of all water entering any excavation including leakage from the existing water main which is to be replaced. All excavations associated with the Work must be kept dry. Water must not be allowed to rise over, or to come in contact with, masonry and concrete until the concrete and mortar has attained a set satisfactory to the Commissioner and, in any event, no sooner than twelve (12) hours after placing the masonry or concrete.

B. Groundwater Levels

1. The Contractor must maintain the groundwater level at least 12-Inches below the bottom of the excavation until the excavation until the Work has been completely and the excavation has been backfilled.

C. Water Management

1. Water pumped or drained from the Work must be disposed of in a suitable manner without damage to adjacent property, other Work under construction, street pavement, and parks. Water must not be discharged onto streets without adequate protection at the point of discharge. No water

containing settleable solids may be discharged into sewers.

2. All damages caused by dewatering the Work must be the responsibility of the Contractor and must be promptly repaired at the Contractor's expense.

3. Limit dewatering flow rates to current operating capacity of City sewers. See Section 01 11 00 for any limitations on discharge rates.

D. Pumping, Bailing and Diversion

1. The Contractor must at all times during construction provide and maintain ample means and devices for the temporary diversion of flow in existing sewers and drains and the prompt removal and proper disposal of all water or sewage entering the tunnels, trenches or other parts of the work, and must keep said excavations as dry as practicable until the structures to be built therein is completed. All water pumped or drained from the work and from existing sewers must be disposed of in a suitable manner without damage to adjacent property, or to sewers, pavements, electrical conduits or other work or property. The Contractor must provide all temporary flumes or pipe lines and pumping equipment required for the proper diversion of sewage and removal of drainage from the work.

2. Whenever the Contractor removes an existing bulkhead, he must install a screen suitable for the purpose of preventing construction debris from floating into the completed portions of the sewer system. As work progresses, Contractor must clean the completed portions of the sewer by removing rails, jacks, lumber, sandbags and all other construction equipment, excess material and debris.

3. The Contractor must place and maintain all temporary dams, flumes, bulkheads or other structures necessary to prevent water from adjacent sections of the sewer system from entering the work under this Contract in such a manner as to injure it, and must completely remove all such temporary structures from the completed portion of the work as rapidly as practicable. The Contractor must not place a dam, flume or bulkhead in any sewer without first obtaining the approval of the Commissioner. The Contractor must ascertain the possibility of sewage backing up into basements and causing damage and he will be held responsible for any such damage.

4. The City does not assume responsibility for providing the Contractor with an outlet for any storm water or sewage which must be disposed of during the construction work under this Contract. Until the acceptance of the work, the Contractor will, if so ordered by the Commissioner, keep the entire work pumped free of water and sewage and before the acceptance of any part of the work. Contractor must clean the entire length of such finished part of the

work to the satisfaction of the Commissioner.

5. Water must not be allowed to flow over or stand on the pipe or structure invert in such a manner as to cause scouring of the surface.

APPENDIX D

ILLINOIS DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISIONS

INDEX
FOR
SUPPLEMENTAL SPECIFICATIONS
AND RECURRING SPECIAL PROVISIONS

Adopted January 1, 2019

This index contains a listing of SUPPLEMENTAL SPECIFICATIONS and frequently used RECURRING SPECIAL PROVISIONS.

ERRATA Standard Specifications for Road and Bridge Construction (Adopted 4-1-16) (Revised 1-1-19)

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RECURRING SPECIAL PROVISIONS

The following RECURRING SPECIAL PROVISIONS indicated by an "X" are applicable to this contract and are included by reference:

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FRICTION AGGREGATE (D-1)

Effective: January 1, 2011
Revised: April 29, 2016

Revise Article 1004.03(a) of the Standard Specifications to read:

"**1004.03 Coarse Aggregate for Hot-Mix Asphalt (HMA).** The aggregate shall be according to Article 1004.01 and the following.

(a) Description. The coarse aggregate for HMA shall be according to the following table.

Use	Mixture	Aggregates Allowed
Class A	Seal or Cover	Allowed Alone or in Combination [5/]: Gravel Crushed Gravel Carbonate Crushed Stone Crystalline Crushed Stone Crushed Sandstone Crushed Slag (ACBF) Crushed Steel Slag Crushed Concrete
HMA Low ESAL	Stabilized Subbase or Shoulders	Allowed Alone or in Combination [5/]: Gravel Crushed Gravel Carbonate Crushed Stone Crystalline Crushed Stone Crushed Sandstone Crushed Slag (ACBF) Crushed Steel Slag[1/] Crushed Concrete
HMA High ESAL Low ESAL	Binder IL-19.0 or IL-19.0L SMA Binder	Allowed Alone or in Combination [5/ 6/]: Crushed Gravel Carbonate Crushed Stone[2/] Crystalline Crushed Stone Crushed Sandstone Crushed Slag (ACBF) Crushed Concrete[3/]

<table>
<tr><th>Use</th><th>Mixture</th><th>Aggregates Allowed</th></tr>
<tr><td>HMA
High ESAL
Low ESAL</td><td>C Surface and Leveling Binder
IL-9.5 or IL-9.5L

SMA
Ndesign 50
Surface</td><td><u>Allowed Alone or in Combination</u> [5/]:

Crushed Gravel
Carbonate Crushed Stone[2/]
Crystalline Crushed Stone
Crushed Sandstone
Crushed Slag (ACBF)
Crushed Steel Slag[4/]
Crushed Concrete[3/]</td></tr>
<tr><td rowspan="5">HMA
High ESAL</td><td rowspan="5">D Surface and Leveling Binder
IL-9.5

SMA
Ndesign 50
Surface</td><td><u>Allowed Alone or in Combination</u> [5/]:

Crushed Gravel
Carbonate Crushed Stone (other than Limestone)[2/]
Crystalline Crushed Stone
Crushed Sandstone
Crushed Slag (ACBF)
Crushed Steel Slag[4/]
Crushed Concrete[3/]</td></tr>
<tr><td><u>Other Combinations Allowed:</u>
<table><tr><th>Up to...</th><th>With...</th></tr><tr><td>25% Limestone</td><td>Dolomite</td></tr><tr><td>50% Limestone</td><td>Any Mixture D aggregate other than Dolomite</td></tr><tr><td>75% Limestone</td><td>Crushed Slag (ACBF) or Crushed Sandstone</td></tr></table></td></tr>
<tr><td rowspan="3">HMA
High ESAL</td><td rowspan="3">E Surface
IL-9.5

SMA
Ndesign 80
Surface</td><td><u>Allowed Alone or in Combination</u> [5/ 6/]:

Crystalline Crushed Stone
Crushed Sandstone
Crushed Slag (ACBF)
Crushed Steel Slag

No Limestone.</td></tr>
<tr><td><u>Other Combinations Allowed:</u>
<table><tr><th>Up to...</th><th>With...</th></tr><tr><td>50% Dolomite[2/]</td><td>Any Mixture E aggregate</td></tr></table></td></tr>
</table>

Use	Mixture	Aggregates Allowed	
		75% Dolomite[2/]	Crushed Sandstone, Crushed Slag (ACBF), Crushed Steel Slag, or Crystalline Crushed Stone
		75% Crushed Gravel[2/] or Crushed Concrete[3/]	Crushed Sandstone, Crystalline Crushed Stone, Crushed Slag (ACBF), or Crushed Steel Slag
HMA High ESAL	F Surface IL-9.5 SMA Ndesign 80 Surface	<u>Allowed Alone or in Combination</u> [5/ 6/]: Crystalline Crushed Stone Crushed Sandstone Crushed Slag (ACBF) Crushed Steel Slag No Limestone.	
		<u>Other Combinations Allowed</u>:	
		Up to...	*With...*
		50% Crushed Gravel[2/], Crushed Concrete[3/], or Dolomite[2/]	Crushed Sandstone, Crushed Slag (ACBF), Crushed Steel Slag, or Crystalline Crushed Stone

1/ Crushed steel slag allowed in shoulder surface only.

2/ Carbonate crushed stone (limestone) and/or crushed gravel shall not be used in SMA Ndesign 80. In SMA Ndesign 50, carbonate crushed stone shall not be blended with any of the other aggregates allowed alone in Ndesign 50 SMA binder or Ndesign 50 SMA surface.

3/ Crushed concrete will not be permitted in SMA mixes.

4/ Crushed steel slag shall not be used as leveling binder.

5/ When combinations of aggregates are used, the blend percent measurements shall be by volume."

6/ Combining different types of aggregate will not be permitted in SMA Ndesign 80."

AGGREGATE SUBGRADE IMPROVEMENT (D-1)

Effective: February 22, 2012
Revised: April 1, 2016

Add the following Section to the Standard Specifications:

“SECTION 303. AGGREGATE SUBGRADE IMPROVEMENT

303.01 Description. This work shall consist of constructing an aggregate subgrade improvement.

303.02 Materials. Materials shall be according to the following.

	Item	Article/Section
(a)	Coarse Aggregate	1004.07
(b)	Reclaimed Asphalt Pavement (RAP) (Notes 1, 2 and 3)	1031

Note 1. Crushed RAP, from either full depth or single lift removal, may be mechanically blended with aggregate gradation CS 01 but shall not exceed 40 percent by weight of the total product. The top size of the Coarse RAP shall be less than 4 in. (100 mm) and well graded.

Note 2. RAP having 100 percent passing the 1 1/2 in (37.5 mm) sieve and being well graded, may be used as capping aggregate in the top 3 in. (75 mm) when aggregate gradation CS 01 is used in lower lifts. When RAP is blended with any of the coarse aggregates, the blending shall be done with mechanically calibrated feeders. The final product shall not contain more than 40 percent by weight of RAP.

Note 3. The RAP used for aggregate subgrade improvement shall be according to the current Bureau of Materials and Physical Research Policy Memorandum, “Reclaimed Asphalt Pavement (RAP) for Aggregate Applications”.

303.03 Equipment. The vibratory machine shall be according to Article 1101.01, or as approved by the Engineer. The calibration for the mechanical feeders shall have an accuracy of ± 2.0 percent of the actual quantity of material delivered.

303.04 Soil Preparation. The stability of the soil shall be according to the Department’s Subgrade Stability Manual for the aggregate thickness specified.

303.05 Placing Aggregate. The maximum nominal lift thickness of aggregate gradation CS 01 shall be 24 in. (600 mm).

303.06 Capping Aggregate. The top surface of the aggregate subgrade shall consist of a minimum 3 in. (75 mm) of aggregate gradations CA 06 or CA 10. When Reclaimed Asphalt Pavement (RAP) is used, it shall be crushed and screened where 100 percent is passing the 1 1/2 in. (37.5 mm) sieve and being well graded. RAP that has been fractionated to size will not be permitted for use in capping. Capping aggregate will not be required when the aggregate subgrade improvement is used as a cubic yard pay item for undercut applications. When RAP is blended with any of the coarse aggregates, the blending shall be done with mechanically calibrated feeders.

303.07 Compaction. All aggregate lifts shall be compacted to the satisfaction of the Engineer. If the moisture content of the material is such that compaction cannot be obtained, sufficient water shall be added so that satisfactory compaction can be obtained.

303.08 Finishing and Maintenance of Aggregate Subgrade Improvement. The aggregate subgrade improvement shall be finished to the lines, grades, and cross sections shown on the plans, or as directed by the Engineer. The aggregate subgrade improvement shall be maintained in a smooth and compacted condition.

303.09 Method of Measurement. This work will be measured for payment according to Article 311.08.

303.10 Basis of Payment. This work will be paid for at the contract unit price per cubic yard (cubic meter) for AGGREGATE SUBGRADE IMPROVEMENT or at the contract unit price per square yard (square meter) for AGGREGATE SUBGRADE IMPROVEMENT, of the thickness specified.

Add the following to Section 1004 of the Standard Specifications:

"1004.07 Coarse Aggregate for Aggregate Subgrade Improvement. The aggregate shall be according to Article 1004.01 and the following.

(a) Description. The coarse aggregate shall be crushed gravel, crushed stone, or crushed concrete. The top 12 inches of the aggregate subgrade improvement shall be 3 inches of capping material and 9 inches of crushed gravel, crushed stone or crushed concrete. In applications where greater than 36 inches of subgrade material is required, rounded gravel, meeting the CS01 gradation, may be used beginning at a depth of 12 inches below the bottom of pavement.

(b) Quality. The coarse aggregate shall consist of sound durable particles reasonably free of deleterious materials. Non-mechanically blended RAP may be allowed up to a maximum of 5.0 percent.

(c) Gradation.

(1) The coarse aggregate gradation for total subgrade thicknesses of 12 in. (300 mm) or greater shall be CS 01.

Grad No.	COARSE AGGREGATE SUBGRADE GRADATIONS Sieve Size and Percent Passing				
	8"	6"	4"	2"	#4
CS 01	100	97 ± 3	90 ± 10	45 ± 25	20 ± 20

Grad No.	COARSE AGGREGATE SUBGRADE GRADATIONS (Metric) Size and Percent Passing				
	200 mm	150 mm	100 mm	50 mm	4.75 mm
CS 01		3	10	25	20

(2) The 3 in. (75 mm) capping aggregate shall be gradation CA 6 or CA 10.

COARSE AGGREGATE FOR BACKFILL, TRENCH BACKFILL AND BEDDING (D-1)

Effective: November 1, 2011
Revised: November 1, 2013

This work shall be according to Section 1004.05 of the Standard Specifications except for the following:

Reclaimed Asphalt Pavement (RAP) maybe blended with gravel, crushed gravel, crushed stone crushed concrete, crushed slag, chats, crushed stone or wet bottom boiler slag. The RAP used shall be according to the current Bureau of Materials and Physical Research Policy Memorandum, "Reclaimed Asphalt Pavement (RAP) for Aggregate Applications". The RAP shall be uniformly graded and shall pass the 1.0 in. (25 mm) screen. When RAP is blended with any of the coarse aggregate listed above, the blending shall be done mechanically with calibrated feeders. The feeders shall have an accuracy of ± 2.0 percent of the actual quantity of material delivered. The final blended product shall not contain more than 40 percent by weight RAP.

The coarse aggregate listed above shall meet CA 6 and CA 10 gradations prior to being blended with the processed and uniformly graded RAP. Gradation deleterious count shall not exceed 10% of total RAP and 5% of other by total weight.

GROUND TIRE RUBBER (GTR) MODIFIED ASPHALT BINDER (D-1)

Effective: June 26, 2006
Revised: April 1, 2016

Add the following to the end of article 1032.05 of the Standard Specifications:

"(c) Ground Tire Rubber (GTR) Modified Asphalt Binder. A quantity of 10.0 to 14.0 percent GTR (Note 1) shall be blended by dry unit weight with a PG 64-28 to make a GTR 70-28 or a PG 58-28 to make a GTR 64-28. The base PG 64-28 and PG 58-28 asphalt binders shall meet the requirements of Article 1032.05(a). Compatible polymers may be added during production. The GTR modified asphalt binder shall meet the requirements of the following table.

Test	Asphalt Grade GTR 70-28	Asphalt Grade GTR 64-28
Flash Point (C.O.C.), AASHTO T 48, °F (°C), min.	450 (232)	450 (232)
Rotational Viscosity, AASHTO T 316 @ 275 °F (135 °C), Poises, Pa·s, max.	30 (3)	30 (3)
Softening Point, AASHTO T 53, °F (°C), min.	135 (57)	130 (54)
Elastic Recovery, ASTM D 6084, Procedure A (sieve waived) @ 77 °F, (25 °C), aged, ss,100 mm elongation, 5 cm/min., cut immediately, %, min.	65	65

Note 1. GTR shall be produced from processing automobile and/or light truck tires by the ambient grinding method. GTR shall not exceed 1/16 in. (2 mm) in any dimension and shall contain no free metal particles or other materials. A mineral powder (such as talc) meeting the requirements of AASHTO M 17 may be added, up to a maximum of four percent by weight of GTR to reduce sticking and caking of the GTR particles. When tested in accordance with Illinois modified AASHTO T 27, *a* 50 g sample of the GTR shall conform to the following graduation requirements:

Sieve Size	Percent Passing
No. 16 (1.18 mm)	100
No. 30 (600 µm)	95 ± 5
No. 50 (300 µm)	> 20

Add the following to the end of Note 1. of article 1030.03 of the Standard Specifications:

"A dedicated storage tank for the Ground Tire Rubber (GTR) modified asphalt binder shall be provided. This tank must be capable of providing continuous mechanical mixing throughout by continuous agitation and recirculation of the asphalt binder to provide a uniform mixture. The tank shall be heated and capable of maintaining the temperature of the asphalt binder at 300 °F to 350 °F (149 °C to 177 °C). The asphalt binder metering systems of dryer drum plants shall be calibrated with the actual GTR modified asphalt binder material with an accuracy of ± 0.40 percent."

Revise 1030.02(c) of the Standard Specifications to read:

"(c) RAP Materials (Note 5) ……..…..1031"

Add the following note to 1030.02 of the Standard Specifications:

Note 5. When using reclaimed asphalt pavement and/or reclaimed asphalt shingles, the maximum asphalt binder replacement percentage shall be according to the most recent special provision for recycled materials.

HMA MIXTURE DESIGN REQUIREMENTS (D-1)

Effective: January 1, 2013
Revised: January 1, 2018

1) Design Composition and Volumetric Requirements

Revise the table in Article 406.06(d) of the Standard Specifications to read:

"MINIMUM COMPACTED LIFT THICKNESS	
Mixture Composition	Thickness, in. (mm)
IL-4.75	3/4 (19)
SMA-9.5, IL-9.5, IL-9.5L	1 1/2 (38)
SMA-12.5	2 (50)
IL-19.0, IL-19.0L	2 1/4 (57)"

Revise the table in Article 1004.03(c) of the Standard Specifications to read:

"Use	Size/Application	Gradation No.
Class A-1, 2, & 3	3/8 in. (10 mm) Seal	CA 16
Class A-1	1/2 in. (13 mm) Seal	CA 15
Class A-2 & 3	Cover	CA 14
HMA High ESAL	IL-19.0 IL-9.5	CA 11 [1/] CA 16, CA 13[3/]
HMA Low ESAL	IL-19.0L IL-9.5L Stabilized Subbase or Shoulders	CA 11 [1/] CA 16
SMA[2/]	1/2 in. (12.5mm) Binder & Surface IL 9.5 Surface	CA13[3/], CA14 or CA16 CA16, CA 13[3/]

1. CA 16 or CA 13 may be blended with the gradations listed.
2. The coarse aggregates used shall be capable of being combined with stone sand, slag sand, or steel slag sand meeting the FA/FM 20 gradation and mineral filler to meet the approved mix design and the mix requirements noted herein.
3. CA 13 shall be 100 percent passing the 1/2 in. (12.5mm) sieve.

Revise Article 1004.03(e) of the Supplemental Specifications to read:

"(e) Absorption. For SMA the coarse aggregate shall also have water absorption ≤ 2.0 percent."

Revise the last paragraph of Article 1102.01 (a) (5) of the Standard Specifications to read:

"IL-4.75 and Stone Matrix Asphalt (SMA) mixtures which contain aggregate having absorptions greater than or equal to 2.0 percent, or which contain steal slag sand, shall have minimum surge bin storage plus haul time of 1.5 hours."

Revise the nomenclature table in Article 1030.01 of the Standard Specifications to read:

"High ESAL	IL-19.0 binder; IL-9.5 surface; IL-4.75; SMA-12.5, SMA-9.5
Low ESAL	IL-19.0L binder; IL-9.5L surface; Stabilized Subbase (HMA)[1/]; HMA Shoulders[2/]

1. Uses 19.0L binder mix.

2. Uses 19.0L for lower lifts and 9.5L for surface lift.

Revise Article 1030.02 of the Standard Specifications and Supplemental Specifications to read:

1030.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Coarse Aggregate	1004.03
(b) Fine Aggregate	1003.03
(c) RAP Material	1031
(d) Mineral Filler	1011
(e) Hydrated Lime	1012.01
(f) Slaked Quicklime (Note 1)	
(g) Performance Graded Asphalt Binder (Note 2)	1032
(h) Fibers (Note 3)	
(i) Warm Mix Asphalt (WMA) Technologies (Note 4)	

Note 1. Slaked quicklime shall be according to ASTM C 5.

Note 2. The asphalt binder shall be an SBS PG 76-28 when the SMA is used on a full-depth asphalt pavement and SBS PG 76-22 when used as an overlay, except where modified herein. The asphalt binder shall be an Elvaloy or SBS PG 76-22 for IL-4.75, except where modified herein. The elastic recovery shall be a minimum of 80.

Note 3. A stabilizing additive such as cellulose or mineral fiber shall be added to the SMA mixture according to Illinois Modified AASHTO M 325. The stabilizing additive shall meet the Fiber Quality Requirements listed in Illinois Modified AASHTO M 325. Prior to approval and use of fibers, the Contractor shall submit a notarized certification by the producer of these materials stating they meet these requirements. Reclaimed Asphalt Shingles (RAS) may be used in Stone Matrix Asphalt (SMA) mixtures designed with an SBA polymer modifier as a fiber additive if the mix design with RAS included meets AASHTO T305 requirements. The RAS shall be from a certified source that produces either Type I or Type 2. Material shall meet requirements noted herein and the actual dosage rate will be determined by the Engineer.

Note 4. Warm mix additives or foaming processes shall be selected from the current Bureau of Materials and Physical Research Approved List, "Warm Mix Asphalt Technologies".

Revise Article 1030.04(a)(1) of the Standard Specifications and the Supplemental Specifications to read:

(1) High ESAL Mixtures. The Job Mix Formula (JMF) shall fall within the following limits.

High ESAL, MIXTURE COMPOSITION (% PASSING) [1/]										
Sieve Size	IL-19.0 mm		SMA [4/] IL-12.5 mm		SMA [4/] IL-9.5 mm		IL-9.5 mm		IL-4.75 mm	
	min	max	min	max	min	max	min	max	min	max
1 1/2 in (37.5 mm)										
1 in. (25 mm)		100								
3/4 in. (19 mm)	90	100		100						
1/2 in. (12.5 mm)	75	89	80	100		100		100		100
3/8 in. (9.5 mm)				65	90	100	90	100		100
#4 (4.75 mm)	40	60	20	30	36	50	34	69	90	100
#8 (2.36 mm)	20	42	16	24 [5/]	16	32 [5/]	34 [6/]	52 [2/]	70	90
#16 (1.18 mm)	15	30					10	32	50	65
#30 (600 µm)			12	16	12	18				
#50 (300 µm)	6	15					4	15	15	30
#100 (150 µm)	4	9					3	10	10	18
#200 (75 µm)	3	6	7.0	9.0 [3/]	7.5	9.5 [3/]	4	6	7	9 [3/]
Ratio Dust/Asphalt Binder		1.0		1.5		1.5		1.0		

1. Based on percent of total aggregate weight.

2. The mixture composition shall not exceed 44 percent passing the #8 (2.36 mm) sieve for surface courses with Ndesign = 90.

3. Additional minus No. 200 (0.075 mm) material required by the mix design shall be mineral filler, unless otherwise approved by the Engineer.

4. The maximum percent passing the #635 (20 µm) sieve shall be ≤ 3 percent.

5. When establishing the Adjusted Job Mix Formula (AJMF) the percent passing the #8 (2.36 mm) sieve shall not be adjusted above the percentage stated on the table.

6. When establishing the Adjusted Job Mix Formula (AJMF) the percent passing the #8 (2.36 mm) sieve shall not be adjusted below 34 percent.

Revise Article 1030.04(b)(1) of the Standard Specifications to read:

(1) High ESAL Mixtures. The target value for the air voids of the HMA shall be 4.0 percent and for IL-4.75 it shall be 3.5 percent at the design number of gyrations. The VMA and VFA of the HMA

design shall be based on the nominal maximum size of the aggregate in the mix, and shall conform to the following requirements.

VOLUMETRIC REQUIREMENTS High ESAL				
	Voids in the Mineral Aggregate (VMA), % minimum			Voids Filled with Asphalt Binder (VFA), %
Ndesign	IL-19.0	IL-9.5	IL-4.75[1/]	
50	13.5	15.0	18.5	65 – 78 [2/]
70				65 - 75
90				

1/ Maximum Draindown for IL-4.75 shall be 0.3 percent

2/ VFA for IL-4.75 shall be 72-85 percent"

Replace Article 1030.04(b)(3) of the Standard Specifications with the following:

(3) SMA Mixtures.

Volumetric Requirements SMA [1/]			
Ndesign	Design Air Voids Target %	Voids in the Mineral Aggregate (VMA), % min.	Voids Filled with Asphalt (VFA), %
80 [4/]	3.5	17.0 [2/] 16.0 [3/]	75 - 83

1. Maximum draindown shall be 0.3 percent. The draindown shall be determined at the JMF asphalt binder content at the mixing temperature plus 30 °F.

2. Applies when specific gravity of coarse aggregate is ≥ 2.760.

3. Applies when specific gravity of coarse aggregate is < 2.760.

4. Blending of different types of aggregate will not be permitted. For surface course, the coarse aggregate can be crushed steel slag, crystalline crushed stone or crushed sandstone. For binder course, coarse aggregate shall be crushed stone (dolomite), crushed gravel, crystalline crushed stone, or crushed sandstone.

Add to the end of Article 1030.05 (d) (2) a. of the Standard Specifications:

"During production, the Contractor shall test SMA mixtures for draindown according to AASHTO T305 at a frequency of 1 per day of production."

Delete last sentence of the second paragraph of Article 1102.01(a) (4) b. 2.

Add to the end of Article 1102.01 (a) (4) b. 2.:

"As an option, collected dust (baghouse) may be used in lieu of manufactured mineral filler according to the following:

(a.) Sufficient collected dust (baghouse) is available for production of the SMA mix for the entire project.

(b.) A mix design was prepared based on collected dust (baghouse).

2) Design Verification and Production

Revise Article 1030.04 (d) of the Standard Specifications to read:

(d) Verification Testing. High ESAL, IL-4.75, and SMA mix designs submitted for verification will be tested to ensure that the resulting mix designs will pass the required criteria for the Hamburg Wheel Test (IL mod AASHTO T-324) and the Tensile Strength Test (IL mod AASHTO T-283). The Department will perform a verification test on gyratory specimens compacted by the Contractor. If the mix fails the Department's verification test, the Contractor shall make the necessary changes to the mix and resubmit compacted specimens to the Department for verification. If the mix fails again, the mix design will be rejected.

All new and renewal mix designs will be required to be tested, prior to submittal for Department verification and shall meet the following requirements:

(1)Hamburg Wheel Test criteria. The maximum allowable rut depth shall be 0.5 in. (12.5 mm). The minimum number of wheel passes at the 0.5 in. (12.5 mm) rut depth criteria shall be based on the high temperature binder grade of the mix as specified in the mix requirements table of the plans.

Illinois Modified AASHTO T 324 Requirements [1/]

Asphalt Binder Grade	# Repetitions	Max Rut Depth (mm)
PG 70 -XX (or higher)	20,000	12.5
PG 64 -XX (or lower)	10,000	12.5

1. When produced at temperatures of 275 ± 5 °F (135 ± 3 °C) or less, loose Warm Mix Asphalt shall be oven aged at 270 ± 5 °F (132 ± 3 °C) for two hours prior to gyratory compaction of Hamburg Wheel specimens.

Note: For SMA Designs (N-80) the maximum rut depth is 6.0 mm at 20,000 repetitions.
For IL 4.75mm Designs (N-50) the maximum rut depth is 9.0mm at 15,000 repetitions.

(2)Tensile Strength Criteria. The minimum allowable conditioned tensile strength shall be 60 psi (415 kPa) for non-polymer modified performance graded (PG) asphalt binder and 80 psi (550 kPa) for polymer modified PG asphalt binder. The maximum allowable unconditioned tensile strength shall be 200 psi (1380 kPa)."

Production Testing. Revise first paragraph of Article 1030.06(a) of the Standard Specifications to read:

"(a) High ESAL, IL-4.75, WMA, and SMA Mixtures. For each contract, a 300 ton (275 metric tons) test strip, except for SMA mixtures it will be 400 ton (363 metric ton), will be required at the beginning of HMA production for each mixture at the beginning of each construction year according to the Manual of Test Procedures for Materials "Hot Mix Asphalt Test Strip Procedures". At the request of the Producer, the Engineer may waive the test strip if previous construction during the current construction year has demonstrated the constructability of the mix using Department test results."

Add the following after the sixth paragraph in Article 1030.06 (a) of the Standard Specifications:

"The Hamburg Wheel test shall also be conducted on all HMA mixtures from a sample taken within the first 500 tons (450 metric tons) on the first day of production or during start up with a split reserved for the Department. The mix sample shall be tested according to the Illinois Modified AASHTO T 324 and shall meet the requirements specified herein. Mix production shall not exceed 1500 tons (1350 metric tons) or one day's production, whichever comes first, until the testing is completed and the mixture is found to be in conformance. The requirement to cease mix production may be waived if the plant produced mixture demonstrates conformance prior to start of mix production for a contract. If the mixture fails to meet the Hamburg Wheel criteria, no further mixture will be accepted until the Contractor takes such action as is necessary to furnish a mixture meeting the criteria"

Method of Measurement:

Add the following after the fourth paragraph of Article 406.13 (b):

"The plan quantities of SMA mixtures shall be adjusted using the actual approved binder and surface Mix Design's G_{mb}."

Basis of Payment.

Replace the fourth paragraph of Article 406.14 of the Standard Specifications with the following:

"Stone matrix asphalt will be paid for at the contract unit price per ton (metric ton) for POLYMERIZED HOT-MIX ASPHALT SURFACE COURSE, STONE MATRIX ASPHALT, of the mixture composition and Ndesign specified; and POLYMERIZED HOT-MIX ASPHALT BINDER COURSE, STONE MATRIX ASPHALT, of the mixture composition and Ndesign specified."

RECLAIMED ASPHALT PAVEMENT AND RECLAIMED ASPHALT SHINGLES (D-1)

Effective: November 1, 2012
Revise: January 1, 2018

Revise Section 1031 of the Standard Specifications to read:

"**SECTION 1031. RECLAIMED ASPHALT PAVEMENT AND RECLAIMED ASPHALT SHINGLES**

1031.01 Description. Reclaimed asphalt pavement and reclaimed asphalt shingles shall be according to the following.

(a) Reclaimed Asphalt Pavement (RAP). RAP is the material resulting from cold milling or crushing an existing hot-mix asphalt (HMA) pavement. RAP will be considered processed FRAP after completion

of both crushing and screening to size. The Contractor shall supply written documentation that the RAP originated from routes or airfields under federal, state, or local agency jurisdiction.

(b) Reclaimed Asphalt Shingles (RAS). Reclaimed asphalt shingles (RAS). RAS is from the processing and grinding of preconsumer or post-consumer shingles. RAS shall be a clean and uniform material with a maximum of 0.5 percent unacceptable material, as defined in Central Bureau of Materials Policy Memorandum, "Reclaimed Asphalt Shingle (RAS) Sources", by weight of RAS. All RAS used shall come from a Central Bureau of Materials approved processing facility where it shall be ground and processed to 100 percent passing the 3/8 in. (9.5 mm) sieve and 90 percent passing the #4 (4.75 mm) sieve. RAS shall meet the testing requirements specified herein. In addition, RAS shall meet the following Type 1 or Type 2 requirements.

(1) Type 1. Type 1 RAS shall be processed, preconsumer asphalt shingles salvaged from the manufacture of residential asphalt roofing shingles.

(2) Type 2. Type 2 RAS shall be processed post-consumer shingles only, salvaged from residential, or four unit or less dwellings not subject to the National Emission Standards for Hazardous Air Pollutants (NESHAP).

1031.02 Stockpiles. RAP and RAS stockpiles shall be according to the following.

(a) RAP Stockpiles. The Contractor shall construct individual, sealed RAP stockpiles meeting one of the following definitions. Additional processed RAP (FRAP) shall be stockpiled in a separate working pile, as designated in the QC Plan, and only added to the sealed stockpile when test results for the working pile are complete and are found to meet tolerances specified herein for the original sealed FRAP stockpile. Stockpiles shall be sufficiently separated to prevent intermingling at the base. All stockpiles (including unprocessed RAP and FRAP) shall be identified by signs indicating the type as listed below (i.e. "Non- Quality, FRAP -#4 or Type 2 RAS", etc…).

(1) Fractionated RAP (FRAP). FRAP shall consist of RAP from Class I, HMA (High and Low ESAL) or equivalent mixtures. The coarse aggregate in FRAP shall be crushed aggregate and may represent more than one aggregate type and/or quality, but shall be at least C quality. All FRAP shall be processed prior to testing and sized into fractions with the separation occurring on or between the #4 (4.75 mm) and 1/2 in. (12.5 mm) sieves. Agglomerations shall be minimized such that 100 percent of the RAP in the coarse fraction shall pass the maximum sieve size specified for the mix the FRAP will be used in.

(2) Restricted FRAP (B quality) stockpiles shall consist of RAP from Class I, HMA (High ESAL), or HMA (High ESAL). If approved by the Engineer, the aggregate from a maximum 3.0 in. (75 mm) single combined pass of surface/binder milling will be classified as B quality. All millings from this application will be processed into FRAP as described previously.

(3) Conglomerate. Conglomerate RAP stockpiles shall consist of RAP from Class I, HMA (High and Low ESAL) or equivalent mixtures. The coarse aggregate in this RAP shall be crushed aggregate and may represent more than one aggregate type and/or quality, but shall be at least C quality. This RAP may have an inconsistent gradation and/or asphalt binder content prior to processing. All conglomerate RAP shall be processed (FRAP) prior to testing. Conglomerate RAP stockpiles shall not contain steel slag or other expansive material as determined by the Department.

(4) Conglomerate "D" Quality (DQ). Conglomerate DQ RAP stockpiles shall consist of RAP from HMA shoulders, bituminous stabilized subbases or HMA (Low ESAL)/HMA (Low ESAL) IL-19.0L

binder mixture. The coarse aggregate in this RAP may be crushed or round but shall be at least D quality. This RAP may have an inconsistent gradation and/or asphalt binder content. Conglomerate DQ RAP stockpiles shall not contain steel slag or other expansive material as determined by the Department.

(5) Non-Quality. RAP stockpiles that do not meet the requirements of the stockpile categories listed above shall be classified as "Non-Quality".

RAP or FRAP containing contaminants, such as earth, brick, sand, concrete, sheet asphalt, bituminous surface treatment (i.e. chip seal), pavement fabric, joint sealants, plant cleanout etc., will be unacceptable unless the contaminants are removed to the satisfaction of the Engineer. Sheet asphalt shall be stockpiled separately.

(b) RAS Stockpiles. Type 1 and Type 2 RAS shall be stockpiled separately and shall be sufficiently separated to prevent intermingling at the base. Each stockpile shall be signed indicating what type of RAS is present.

However, a RAS source may submit a written request to the Department for approval to blend mechanically a specified ratio of Type 1 RAS with Type 2 RAS. The source will not be permitted to change the ratio of the blend without the Department prior written approval. The Engineer's written approval will be required, to mechanically blend RAS with any fine aggregate produced under the AGCS, up to an equal weight of RAS, to improve workability. The fine aggregate shall be "B Quality" or better from an approved Aggregate Gradation Control System source. The fine aggregate shall be one that is approved for use in the HMA mixture and accounted for in the mix design and during HMA production.

Records identifying the shingle processing facility supplying the RAS, RAS type, and lot number shall be maintained by project contract number and kept for a minimum of three years.

1031.03 Testing. FRAP and RAS testing shall be according to the following.

(a) FRAP Testing. When used in HMA, the FRAP shall be sampled and tested either during processing or after stockpiling. It shall also be sampled during HMA production.

(1) During Stockpiling. For testing during stockpiling, washed extraction samples shall be run at the minimum frequency of one sample per 500 tons (450 metric tons) for the first 2000 tons (1800 metric tons) and one sample per 2000 tons (1800 metric tons) thereafter. A minimum of five tests shall be required for stockpiles less than 4000 tons (3600 metric tons).

(2) Incoming Material. For testing as incoming material, washed extraction samples shall be run at a minimum frequency of one sample per 2000 tons (1800 metric tons) or once per week, whichever comes first.

(3) After Stockpiling. For testing after stockpiling, the Contractor shall submit a plan for approval to the District proposing a satisfactory method of sampling and testing the RAP/FRAP pile either in-situ or by restockpiling. The sampling plan shall meet the minimum frequency required above and detail the procedure used to obtain representative samples throughout the pile for testing.

Before extraction, each field sample of FRAP, shall be split to obtain two samples of test sample size. One of the two test samples from the final split shall be labeled and stored for Department use. The Contractor shall extract the other test sample according to Department procedure. The Engineer reserves the right to test any sample (split or Department-taken) to verify Contractor test results.

(b) RAS Testing. RAS shall be sampled and tested during stockpiling according to Central Bureau of Materials Policy Memorandum, "Reclaimed Asphalt Shingle (RAS) Sources". The Contractor shall also sample as incoming material at the HMA plant.

(1) During Stockpiling. Washed extraction and testing for unacceptable materials shall be run at the minimum frequency of one sample per 200 tons (180 metric tons) for the first 1000 tons (900 metric tons) and one sample per 1000 tons (900 metric tons) thereafter. A minimum of five samples are required for stockpiles less than 1000 tons (900 metric tons). Once a ≤ 1000 ton (900 metric ton), five-sample/test stockpile has been established it shall be sealed. Additional incoming RAS shall be in a separate working pile as designated in the Quality Control plan and only added to the sealed stockpile when the test results of the working pile are complete and are found to meet the tolerances specified herein for the original sealed RAS stockpile.

(2) Incoming Material. For testing as incoming material at the HMA plant, washed extraction shall be run at the minimum frequency of one sample per 250 tons (227 metric tons). A minimum of five samples are required for stockpiles less than 1000 tons (900 metric tons). The incoming material test results shall meet the tolerances specified herein.

The Contractor shall obtain and make available all test results from start of the initial stockpile sampled and tested at the shingle processing facility in accordance with the facility's QC Plan.

Before extraction, each field sample shall be split to obtain two samples of test sample size. One of the two test samples from the final split shall be labeled and stored for Department use. The Contractor shall extract the other test sample according to Department procedures. The Engineer reserves the right to test any sample (split or Department-taken) to verify Contractor test results.

1031.04 Evaluation of Tests. Evaluation of test results shall be according to the following.

(a) Evaluation of FRAP Test Results. All test results shall be compiled to include asphalt binder content, gradation and, when applicable (for slag), G_{mm}. A five test average of results from the original pile will be used in the mix designs. Individual extraction test results run thereafter, shall be compared to the average used for the mix design, and will be accepted if within the tolerances listed below.

Parameter	FRAP
No. 4 (4.75 mm)	± 6 %
No. 8 (2.36 mm)	± 5 %
No. 30 (600 µm)	± 5 %
No. 200 (75 µm)	± 2.0 %
Asphalt Binder	± 0.3 %
G_{mm}	± 0.03 1/

1/ For stockpile with slag or steel slag present as determined in the current Manual of Test Procedures Appendix B 21, "Determination of Reclaimed Asphalt Pavement Aggregate Bulk Specific Gravity".

If any individual sieve and/or asphalt binder content tests are out of the above tolerances when compared to the average used for the mix design, the FRAP stockpile shall not be used in Hot-Mix Asphalt unless the FRAP

representing those tests is removed from the stockpile. All test data and acceptance ranges shall be sent to the District for evaluation.

The Contractor shall maintain a representative moving average of five tests to be used for Hot-Mix Asphalt production.

With the approval of the Engineer, the ignition oven may be substituted for extractions according to the ITP, "Calibration of the Ignition Oven for the Purpose of Characterizing Reclaimed Asphalt Pavement (RAP)" or Illinois Modified AASHTO T-164-11, Test Method A.

(b) Evaluation of RAS Test Results. All of the test results, with the exception of percent unacceptable materials, shall be compiled and averaged for asphalt binder content and gradation. A five test average of results from the original pile will be used in the mix designs. Individual test results run thereafter, when compared to the average used for the mix design, will be accepted if within the tolerances listed below.

Parameter	RAS
No. 8 (2.36 mm)	± 5 %
No. 16 (1.18 mm)	± 5 %
No. 30 (600 µm)	± 4 %
No. 200 (75 µm)	± 2.5 %
Asphalt Binder Content	± 2.0 %

If any individual sieve and/or asphalt binder content tests are out of the above tolerances when compared to the average used for the mix design, the RAS shall not be used in Hot-Mix Asphalt unless the RAS representing those tests is removed from the stockpile. All test data and acceptance ranges shall be sent to the District for evaluation.

(c) Quality Assurance by the Engineer. The Engineer may witness the sampling and splitting conduct assurance tests on split samples taken by the Contractor for quality control testing a minimum of once a month.

The overall testing frequency will be performed over the entire range of Contractor samples for asphalt binder content and gradation. The Engineer may select any or all split samples for assurance testing. The test results will be made available to the Contractor as soon as they become available.

The Engineer will notify the Contractor of observed deficiencies.

Differences between the Contractor's and the Engineer's split sample test results will be considered acceptable if within the following limits.

Test Parameter	Acceptable Limits of Precision	
% Passing:[1/]	FRAP	RAS
1/2 in.	5.0%	
No. 4	5.0%	
No. 8	3.0%	4.0%
No. 30	2.0%	4.0%
No. 200	2.2%	4.0%

Asphalt Binder Content	0.3%	3.0%
G_{mm}	0.030	

1/ Based on washed extraction.

In the event comparisons are outside the above acceptable limits of precision, the Engineer will immediately investigate.

(d) Acceptance by the Engineer. Acceptable of the material will be based on the validation of the Contractor's quality control by the assurance process.

1031.05 Quality Designation of Aggregate in RAP and FRAP.

(a) RAP. The aggregate quality of the RAP for homogeneous, conglomerate, and conglomerate "D" quality stockpiles shall be set by the lowest quality of coarse aggregate in the RAP stockpile and are designated as follows.

(1) RAP from Class I, HMA (High ESAL), or (Low ESAL) IL-9.5L surface mixtures are designated as containing Class B quality coarse aggregate.

(2) RAP from HMA (Low ESAL) IL-19.0L binder mixture is designated as Class D quality coarse aggregate.

(3) RAP from Class I, HMA (High ESAL) binder mixtures, bituminous base course mixtures, and bituminous base course widening mixtures are designated as containing Class C quality coarse aggregate.

(4) RAP from bituminous stabilized subbase and BAM shoulders are designated as containing Class D quality coarse aggregate.

(b) FRAP. If the Engineer has documentation of the quality of the FRAP aggregate, the Contractor shall use the assigned quality provided by the Engineer.

If the quality is not known, the quality shall be determined as follows. Fractionated RAP stockpiles containing plus #4 (4.75 mm) sieve coarse aggregate shall have a maximum tonnage of 5,000 tons (4,500 metric tons). The Contractor shall obtain a representative sample witnessed by the Engineer. The sample shall be a minimum of 50 lb (25 kg). The sample shall be extracted according to Illinois Modified AASHTO T 164 by a consultant laboratory prequalified by the Department for the specified testing. The consultant laboratory shall submit the test results along with the recovered aggregate to the District Office. The cost for this testing shall be paid by the Contractor. The District will forward the sample to the Central Bureau of Materials Aggregate Lab for MicroDeval Testing, according to ITP 327. A maximum loss of 15.0 percent will be applied for all HMA applications. The fine aggregate portion of the fractionated RAP shall not be used in any HMA mixtures that require a minimum of "B" quality aggregate or better, until the coarse aggregate fraction has been determined to be acceptable thru a MicroDeval Testing.

1031.06 Use of FRAP and/or RAS in HMA. The use of FRAP and/or RAS shall be the Contractor's option when constructing HMA in all contracts.

(a) FRAP. The use of FRAP in HMA shall be as follows.

(1) Coarse Aggregate Size (after extraction). The coarse aggregate in all FRAP shall be equal to or less than the nominal maximum size requirement for the HMA mixture to be produced.

(2) Steel Slag Stockpiles. FRAP stockpiles containing steel slag or other expansive material, as determined by the Department, shall be homogeneous and will be approved for use in HMA (High ESAL and Low ESAL) mixtures regardless of lift or mix type.

(3) Use in HMA Surface Mixtures (High and Low ESAL). FRAP stockpiles for use in HMA surface mixtures (High and Low ESAL) shall have coarse aggregate that is Class B quality or better. FRAP shall be considered equivalent to limestone for frictional considerations unless produced/screened to minus 3/8 inch.

(4) Use in HMA Binder Mixtures (High and Low ESAL), HMA Base Course, and HMA Base Course Widening. FRAP stockpiles for use in HMA binder mixtures (High and Low ESAL), HMA base course, and HMA base course widening shall be FRAP in which the coarse aggregate is Class C quality or better.

(5) Use in Shoulders and Subbase. FRAP stockpiles for use in HMA shoulders and stabilized subbase (HMA) shall be FRAP, Restricted FRAP, conglomerate, or conglomerate DQ.

(b) RAS. RAS meeting Type 1 or Type 2 requirements will be permitted in all HMA applications as specified herein.

(c) FRAP and/or RAS Usage Limits. Type 1 or Type 2 RAS may be used alone or in conjunction with FRAP in HMA mixtures up to a maximum of 5.0 percent by weight of the total mix.

When FRAP is used alone or FRAP is used in conjunction with RAS, the percent of virgin asphalt binder replacement (ABR) shall not exceed the amounts indicated in the table below for a given N Design.

Max Asphalt Binder Replacement for FRAP with RAS Combination

HMA Mixtures [1/ 2/ 4/]	Maximum % ABR		
Ndesign	Binder/Leveling Binder	Surface	Polymer Modified [3/]
30L	50	40	30
50	40	35	30
70	40	30	30
90	40	30	30
4.75 mm N-50			40
SMA N-80			30

1. For Low ESAL HMA shoulder and stabilized subbase, the percent asphalt binder replacement shall not exceed 50 % of the total asphalt binder in the mixture.

2. When the binder replacement exceeds 15 % for all mixes, except for SMA and IL-4.75, the high and low virgin asphalt binder grades shall each be reduced by one grade (i.e. 25 % binder replacement using a virgin asphalt binder grade of PG64-22 will be reduced to a PG58-28). When constructing full depth HMA and the ABR is less than 15 %, the required virgin asphalt binder grade shall be PG64-28.

3. When the ABR for SMA or IL-4.75 is 15 % or less, the required virgin asphalt binder shall be SBS PG76-22 and the elastic recovery shall be a minimum of 80. When the ABR for SMA or IL-4.75 exceeds 15%, the virgin asphalt binder grade shall be SBS PG70-28 and the elastic recovery shall be a minimum of 80.

4. When FRAP or RAS is used alone, the maximum percent asphalt binder replacement designated on the table shall be reduced by 10 %.

1031.07 HMA Mix Designs. At the Contractor's option, HMA mixtures may be constructed utilizing RAP/FRAP and/or RAS material meeting the detailed requirements specified herein.

(a) FRAP and/or RAS. FRAP and /or RAS mix designs shall be submitted for verification. If additional FRAP or RAS stockpiles are tested and found to be within tolerance, as defined under "Evaluation of Tests" herein, and meet all requirements herein, the additional FRAP or RAS stockpiles may be used in the original design at the percent previously verified.

(b) RAS. Type 1 and Type 2 RAS are not interchangeable in a mix design.

The RAP, FRAP and RAS stone specific gravities (G_{sb}) shall be according to the "Determination of Aggregate Bulk (Dry) Specific Gravity (G_{sb}) or Reclaimed Asphalt Pavement (RAP) and Reclaimed Asphalt Shingles (RAS)" procedure in the Department's Manual of Test Procedures for Materials.

1031.08 HMA Production. HMA production utilizing FRAP and/or RAS shall be as follows.

To remove or reduce agglomerated material, a scalping screen, gator, crushing unit, or comparable sizing device approved by the Engineer shall be used in the RAS and FRAP feed system to remove or reduce oversized material. .

If during mix production, corrective actions fail to maintain FRAP, RAS or QC/QA test results within control tolerances or the requirements listed herein the Contractor shall cease production of the mixture containing FRAP or RAS and conduct an investigation that may require a new mix design.

(a) RAS. RAS shall be incorporated into the HMA mixture either by a separate weight depletion system or by using the RAP weigh belt. Either feed system shall be interlocked with the aggregate feed or weigh system to maintain correct proportions for all rates of production and batch sizes. The portion of RAS shall be controlled accurately to within ± 0.5 percent of the amount of RAS utilized. When using the weight depletion system, flow indicators or sensing devices shall be provided and interlocked with the plant controls such that the mixture production is halted when RAS flow is interrupted.

(b) HMA Plant Requirements. HMA plants utilizing FRAP and/or RAS shall be capable of automatically recording and printing the following information.

(1) Dryer Drum Plants.

a. Date, month, year, and time to the nearest minute for each print.

b. HMA mix number assigned by the Department.

c. Accumulated weight of dry aggregate (combined or individual) in tons (metric tons) to the nearest 0.1 ton (0.1 metric ton).

d. Accumulated dry weight of RAS and FRAP in tons (metric tons) to the nearest 0.1 ton (0.1 metric ton).

e. Accumulated mineral filler in revolutions, tons (metric tons), etc. to the nearest 0.1 unit.

f. Accumulated asphalt binder in gallons (liters), tons (metric tons), etc. to the nearest 0.1 unit.

g. Residual asphalt binder in the RAS and FRAP material as a percent of the total mix to the nearest 0.1 percent.

h. Aggregate RAS and FRAP moisture compensators in percent as set on the control panel. (Required when accumulated or individual aggregate and RAS and FRAP are printed in wet condition.)

i. When producing mixtures with FRAP and/or RAS, a positive dust control system shall be utilized.

j. Accumulated mixture tonnage.

k. Dust Removed (accumulated to the nearest 0.1 ton (0.1 metric ton))

(2) Batch Plants.

a. Date, month, year, and time to the nearest minute for each print.

b. HMA mix number assigned by the Department.

c. Individual virgin aggregate hot bin batch weights to the nearest pound (kilogram).

d. Mineral filler weight to the nearest pound (kilogram).

f. RAS and FRAP weight to the nearest pound (kilogram).

g. Virgin asphalt binder weight to the nearest pound (kilogram).

h. Residual asphalt binder in the RAS and FRAP material as a percent of the total mix to the nearest 0.1 percent.

The printouts shall be maintained in a file at the plant for a minimum of one year or as directed by the Engineer and shall be made available upon request. The printing system will be inspected by the Engineer prior to production and verified at the beginning of each construction season thereafter.

1031.09 RAP in Aggregate Surface Course and Aggregate Wedge Shoulders, Type B. The use of RAP or FRAP in aggregate surface course and aggregate shoulders shall be as follows.

(a) Stockpiles and Testing. RAP stockpiles may be any of those listed in Article 1031.02, except “Non-Quality” and “FRAP”. The testing requirements of Article 1031.03 shall not apply. RAP used shall be according to the current Central Bureau of Materials Policy Memorandum, “Reclaimed Asphalt Pavement (RAP) for Aggregate Applications”.

(b) Gradation. The RAP material shall meet the gradation requirements for CA 6 according to Article 1004.01(c), except the requirements for the minus No. 200 (75 µm) sieve shall not apply. The sample for the RAP material shall be air dried to constant weight prior to being tested for gradation.”

TEMPORARY INFORMATION SIGNING

Description.
This work shall consist of furnishing, installing, maintaining, relocating for various states of construction and eventually removing temporary informational signs. Included in this item may be ground mount signs, skid mount signs, truss mount signs, bridge mount signs, and overlay sign panels which cover portions of existing signs.

Materials.
Materials shall be according to the following Articles of Section 1000 - Materials:

The overlay panels shall be 0.08 inch (2 mm) thick.

	Item	Article/Section
a.)	Sign Base (Notes 1 & 2)	1090
b.)	Sign Face (Note 3)	1091
c.)	Sign Legends	1092
d.)	Sign Supports	1093
e.)	Overlay Panels (Note 4)	1090.02

Note 1. The Contractor may use 5/8 inch (16 mm) instead of 3/4 inch (19 mm) plywood.
Note 2. Type A sheeting can be used on the plywood base.
Note 3. All sign faces shall be Type A except all orange signs shall meet the requirements of Article 1106.01.
Note 4. The overlay panels shall be 0.08 inch (2 mm) thick.

GENERAL CONSTRUCTION REQUIRMENTS
Installation.
The sign sizes and legend sizes shall be verified by the Contractor prior to fabrication.

Signs which are placed along the roadway and/or within the construction zone shall be installed according to the requirements of Article 701.14 and Article 720.04. The signs shall be 7 ft. (2.1 m) above the near edge of the pavement and shall be a minimum of 2 ft. (600 mm) beyond the edge of the paved shoulder. A minimum of two (2) posts shall be used.

The attachment of temporary signs to existing sign structures or sign panels shall be approved by the Engineer. Any damage to the existing signs due to the Contractor's operations shall be repaired or signs replaced, as determined by the Engineer, at the Contractor's expense.

Signs which are placed on overhead bridge structures shall be fastened to the handrail with stainless steel bands. These signs shall rest on the concrete parapet where possible. The Contractor shall furnish mounting details for approval by the Engineer.

Method of Measurement.
This work shall not be measured for payment.

All hardware, posts or skids, supports, bases for ground mounted signs, connections, which are required for mounting these signs will be included.

Basis Of Payment.
This work shall be paid for at the contract Lump Sum prince for CIVIL WORK

CHANGEABLE MESSAGE SIGN

Description. This work consists of furnishing, installation, maintenance, and removal of changeable message signs required for construction operations and detours for this project as shown on the Plans, as directed by the Engineer, in accordance with the applicable portions of the Standard Specifications, and as herein specified.

Construction Requirements. The Contractor shall install changeable message signs in locations designated by the Engineer at least 7 calendar days prior to entering Stage 1 of the required Maintenance of Traffic plans, and at least 7 calendar days prior to executing the detour route, or for the duration requested by the Department or Kane County Division of Transportation (KDOT).

The Engineer shall work with the Department and KDOT to determine the appropriate message pattern on each board. The Contractor shall input the message as provided by the Engineer. Minor variances to the message may be used with Engineer approval.

The Contractor may relocate the signs as needed to complete work with approval from the Engineer. The signs must remain operational at all times during use, unless a specific operation precludes this. The signs must be re-energized as quickly as possible.

Signs that are determined to be displaying an improper message or no message shall be repaired or replaced within 24 hours of the Contractor receiving written notice from the Engineer of said error.

Method of Measurement. This item will not be measured for payment

Basis of Payment. This work will be included in the contract lump sum price for CIVIL WORK.

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APPENDIX E

CHICAGO TRANSIT AUTHORITY SYSTEM SAFETY: SAFETY MANUAL FOR CONTRACT CONSTRUCTION ON, ABOVE OR ADJACENT TO THE CTA RAIL SYSTEM

Chicago Transit Authority
System Safety

Safety Manual
for Contract Construction
On, Above or Adjacent to the
CTA Rail System

April 2011
Revision No. 3

Baseline: 2002 Manual
Previous Revision: July 2009

Foreword

The Chicago Transit Authority's (CTA) rail system contains billions of dollars in fixed assets, including elevated structure, bridges, rail stations, track, traction power distribution system, signal and communication systems, etc. The rail system is a unique environment, which has very specialized safety rules and procedures to protect employees and customers from moving trains, electrified third rail and other hazards.

Regularly, the CTA or the City of Chicago hires contractors and consultants to replace and modernize fixed assets on the CTA rail system right-of-way. Since these contractors and consultants are not usually familiar with this environment, the CTA developed this Safety Manual for Contract Construction to inform contractors and consultants about the rail system. The purpose of this manual is to give contractors and consultants a basic understanding of the major safety hazards expected to be encountered while working on and around the rail system right-of-way and to support their endeavor of working safely in this environment.

Safety is the responsibility of the contractor or consultant personnel. This manual identifies the contractor's or consultant's responsibilities for knowing, complying with and enforcing the rail system guidelines, rules and procedures, and shall govern the activities of contractors or consultants performing inspection, investigation, design, construction or any other work on, above or adjacent to the CTA rail system. This manual is not to be construed as the only source of the required safety measures to be employed by the contractor or consultant while on, above or adjacent to the CTA right-of-way.

The CTA believes if contractors and consultants know and follow these safety rules and procedures they can perform their work with reasonable efficiency while protecting their own safety and the safety of CTA customers, employees, property and the public while avoiding unnecessary delays to CTA service.

Sara Schwanke
General Manager, Safety & Risk Compliance
Chicago Transit Authority

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Chapter 1: Introduction

1-1 Scope

1-1.1 In providing quality mass transportation services, the Chicago Transit Authority's (CTA) top priority is to maintain the highest standard of safety for passengers, employees, contractors and the general public. The CTA makes every practical effort to prevent injuries and operate safely. To achieve this goal, a comprehensive safety system of operating rules and procedures has been developed by the CTA.

1-1.2 The Safety Manual for Contract Construction On, Above or Adjacent to the CTA Rail System governs any type of construction, engineering or maintenance work performed by contractors and consultants at any location on, above or adjacent to the CTA right-of-way.

1-1.3 The Safety Manual also applies to CTA rail system yards, rail stations, tracks, substations and any other facilities (structures, maintenance shops, etc.), where contractors or consultants are performing work close to moving rail vehicles or to the 600 volt DC traction power distribution system.

1-2 Purpose

1-2.1 It is the intent of the Safety Manual to give contractors and consultants an understanding of the special conditions that exist in and around the CTA right-of-way and to establish the safety rules, procedures and other precautions, which they (and their employees, subcontractors, etc.) shall follow.

1-2.2 The Safety Manual is part of a unified CTA safety program and supplements the Special Conditions Section of any engineering, maintenance or construction contract. The Safety Manual is not intended to amend or supersede any applicable safety standards, design criteria or codes (Chicago or other municipalities' building codes, NFPA, etc.), federal regulations (OSHA, EPA, etc.) or CTA standard operating procedures (SOP).

1-3 Application

1-3.1 The contractor is responsible for overall project safety. The Safety Manual should be applied whenever contractors and consultants perform work on, above or adjacent to the CTA rail system to protect themselves, their employees, sub-contractors, CTA passengers, employees and the public.

1-3.2 It is the responsibility of individuals entering or working in close proximity to the CTA rail system to follow all safety rules and procedures contained or referenced in the Safety Manual. All personnel shall use caution and apply all safe work practices.

1-3.3 The Safety Manual is not addressed to CTA personnel. There is a comprehensive system of CTA standard operating procedures and rail service bulletins directed to rail operating personnel that governs operations throughout the rail system and supports the safe and expeditious movement of trains.

1-3.4 In addition, this CTA safety system of rules includes the Safety Rules book addressed to the CTA bus, rail, engineering and facilities maintenance personnel which enables them to perform

essential work in and around the rail system without placing themselves, passengers or the public in danger.

1-4 Definitions

Authority or CTA means the Chicago Transit Authority acting by and through the Chicago Transit Board or its authorized agent, servant or employee in connection with a contract for an Engineering, Construction or Maintenance project.

Contractor or Consultant refers to the individuals, partnerships, firms, corporations, joint ventures or other entities identified in the contract, including their own personnel and the personnel of any subcontractors.

Contractor Safety Representative (CSR) refers to the individuals (safety engineer, safety supervisor, competent person) designated by the contractor's Safety Management Program (SMP) as having sole responsibility for the management of all safety matters at the construction site.

Construction Inspector refers to the vice president, infrastructure of the Authority or any other person designated by him or her or by the Chicago Transit Board or its authorized agent, servant or employee to be the construction inspector to oversee for compliance of all or any part of the contract documents at a construction site.

Operator refers to the CTA employee having direct and immediate control of the movement of a revenue or work train.

CTA Flagman refers to a CTA employee assigned to control the movement of trains by the display of flag or hand signals, flashing lights, etc.

Person-in-Charge (PIC) a person or persons, specified in a CTA rail service bulletin, who is solely in charge of a work zone and is the single point of contact between the CTA and all persons (contractors, CTA and others) working in a work zone. The rail service bulletin may identify the PIC by name or by radio call number.

Project Manager or Engineer refers to the chief engineer of the Authority or any other person designated by him or her or by the Chicago Transit Board or its authorized agent, servant or employee to be the project manager in charge of the project.

Track Access Occurrence is a condition(s) which provides modification to the normal operation of CTA service to facilitate access for a contractor(s) to perform work on or near the CTA right-of-way as defined and limited in the Attachment H portion of the contract documents.

Right-Of-Way (ROW) Work is any work performed at, above or below track level or within 50 feet of the centerline of track, or any work performed within the ROW unless separated by a physical barrier in compliance with Section 4.5.3 of this manual.

Safety Inspector refers to the general manager, safety & risk compliance of the Authority or any other person/consultant designated by the Chicago Transit Board or its authorized agent,

servant or employee to oversee compliance with the contractor's Safety Management Program (SMP) at a construction site.

NOTE: When a job title is mentioned in the Manual, the expression "or designee" is implied for the execution of the assigned activity.

Any person with authority may delegate the performance of assigned duties to subordinate personnel. This delegation need not be formal or in writing. However, responsibility for those duties cannot be delegated.

Chapter 2: Contractor Training and Other Pre-Requisites

2-1 Contractor Safety Management Program (SMP)

2-1.1 The contractor is responsible for the safety of their employees and others entering their job sites. The contractor is required to provide or secure all safety and health training for contractor personnel working on the project as required by CTA, federal, state and local laws, statutes and regulations.

2-1.2 Within 30 days of the date of the Notice to Proceed (NTP) the contractor shall submit their SMP to the CTA for review and comment. The SMP must comply with the requirements of this section, OSHA, City of Chicago and other regulatory agencies. Work on the project shall not be permitted to start until the full written plan, covering all required items has been submitted and approved.

2-1.3 The Site Specific Safety Plan (SSSP) shall govern all contractor and subcontractor personnel activity and shall address the project health and safety issues including but not limited to the following:

- Management commitment to safety
- Assignment of responsibilities
- Training and education
- Communications
- Safe Work Plan (SWP)
- Identification and control of hazards
- Hazard analysis
- Accident reporting and investigation
- Recordkeeping
- First aid and medical assistance

2-1.4 The contractor's Site Specific Safety Plan (SSSP) shall specify the name of the contractor safety representatives (CSR) (safety engineer, safety supervisor and competent person) assigned to that project and who are responsible for the safe and healthful performance of all work, including that performed by subcontractors. The contractor safety representatives shall ensure that all subcontractors are familiar and comply with the contractor's SSSP.

2-1.5 The contractor shall employ and assign a full-time safety engineer exclusively to this project within two weeks from contract award until its physical completion. The safety engineer's sole

responsibility shall be the management of all safety matters, including those specified in this section. The safety engineer shall have successfully completed the 30-hour OSHA course on Construction Safety and Health (29 CFR 1926). The Authority may accept the other safety certifications or safety training in lieu of the foregoing. The safety engineer shall have not less than ten years of safety or safety-related experience, and shall be familiar with the work being performed and shall be approved by the CTA.

2-1.6 The CSR shall implement and monitor the contractor's and subcontractor's safety programs, make area inspections, conduct Just in Time Training safety meetings, attend construction staging meetings, provide contractor disciplinary action, investigate all accidents and injuries and prepare all accident or injury reports required by CTA, federal, state or local authorities.

2-2 Rail Safety Training

2-2.1 The contractor's and subcontractor's employees assigned to work on, over or near the CTA right-of-way shall be required to attend an all-day rail right-of-way safety training session in accordance with the CTA Safety Manual for Contract Construction On, Above or Adjacent to the CTA Rail System. The training session identifies the dangers that exist on the rail system, including moving trains and the 600-volt DC traction power distribution system, and instructs the students on how to protect themselves while working. The certification is good for one calendar year from the date of issuance. The contractor shall coordinate Rail Safety Training with the CTA project manager.

2-2.2 Generally, one class is conducted each weekday and can accommodate up to eight students in each class. The contractor, subcontractor or consultant must pay the cost of the Rail Safety Training course, "Rail Safety Training Fee," in advance.

2-2.3 The contractor is responsible for requesting Rail Safety Training for contractor or subcontractor employees by providing a letter to the CTA project manager. The letter shall list the full name and last four digit of their social security number of each individual proposed for training. The contractor shall also enclose a check payable to the Chicago Transit Authority including the individual charge for the "Rail Safety Training Fee," multiplied by the number of individuals proposed for training. The contract specification for each project includes the current applicable cost for Rail Safety Training.

The "Rail Safety Training Fee" is non-refundable. If an individual fails to report for training or is rejected for training and must be rescheduled, an additional "Rail Safety Training Fee" will be required.

NOTE: The contractor should be advised that there might be a waiting period for a student to gain admissions into the Rail Safety Training course during certain times of the year.

2-2.4 Upon successful completion of Rail Safety Training, each trainee will be issued a nontransferable Rail Safety Tour Identification Card with the trainee's photo and a decal with pressure sensitive adhesive to be affixed on the hard hat. The Rail Safety Tour Identification Card and the decal are valid for one year from the date of issue. The expiration of the card and the decal are not related to the length of the contract.

2-2.5 The contractor, subcontractor or consultant personnel must renew their Rail Safety Tour Identification Cards annually by successfully completing Rail Safety Training. The contractor's personnel who fail to maintain a valid Rail Safety Tour Identification Card are not permitted to work on, above or adjacent to the CTA rail right-of-way.

2-2.6 The contractor's personnel who are working on the project shall wear approved, non-transferable hard hats while working on, over or adjacent to the CTA rail right-of-way. The Rail Safety Training decal must be affixed to the employee's hardhat. The decal will provide a way for the Safety department or construction inspector to easily identify trained personnel, but is not a substitute for the Rail Safety Tour Identification Card. All employees shall wear an undamaged hard hat with current rail safety sticker affixed, safety vest and eye protection at all times while on CTA right-of-way. Noise protection shall be used when necessary. The contractor must also comply with all OSHA requirements as required for the work. The CTA shall provide the rail safety sticker to each contractor employee upon successful completion of the Rail Safety Training course.

2-2.7 The contractor, subcontractor or consultant must keep the Rail Safety Tour Identification Card on their person at all times. They must be prepared to present this card at all times while working on CTA property. Any work site on the right-of-way is subject to unannounced safety audits by the CTA's Safety department, the CTA construction inspector, the CTA Rail Operations personnel or other CTA official.

2.2.8 The contractor, subcontractor or consultant shall maintain an up-to-date log of all employees working at the construction site including the completion date of the Rail Safety Training.

2-3 Coordination of Construction Activity

2-3.1 After the construction schedule is approved, the contractor shall provide the project manager with the names and telephone numbers of the designated contractor individual in charge of the specific work site(s) and of the designated contractor safety representative (CSR).

2-3.2 No contractor can enter the right-of-way or perform any work affecting the rail transit operations without permission from CTA Rail Operations division.

2-3.3 Prior to a contractor changing a safety critical element of railroad plant, the engineer shall perform a preliminary hazard analysis according to all applicable guidelines (e.g. FTA). When the construction activity is interfering with the rail revenue service, the contractor shall utilize the preliminary hazard analysis in developing the construction schedule (according with contract documents) and to substantiate the staging of the construction activities. At least 21 days before the safety critical element is introduced or altered, the construction inspector shall submit a request to Rail Operations for approval. The Rail Operations division must issue a service bulletin for the training and instruction of operating personnel on that rail line.

2-3.4 After a temporary rail line closure, all components of the rail system, tracks, signals, stations, etc., must be operational, safe and secure prior to putting the tracks back into service. Rail Operations is required to operate a test train to check and verify any new or altered structure, station, track work, traction power or signal prior to running the first passenger train or as directed by the engineer. Additional time shall be allowed by the contractor for any possible remedial work required before the system can be made fully functional. The contractor shall allow enough time prior to putting the tracks back into service to make sure the line can be fully operational. A test train shall be required after any track replacement, signal modification or any construction activity, determined by the engineer, to require a test train. The scheduling of test trains must include travel time to and from the location being tested. Additional time should also be allowed for any possible remedial work required before the system can be made fully operational.

2-3.5 All major work activities should have ample planning and an associated job hazard analysis.

Chapter 3: Work Rules and Procedures on the Rights-of-Way

The CTA provides safe and reliable mass transportation services seven days each week and 24 hours each day. The following work rules and procedures on the CTA rail right-of-way have been developed to provide adequate time and working conditions for contractors to perform construction and other work on the rail system in a safe and efficient manner.

3-1 Periods of Light Ridership

3-1.1 Generally, construction and other work activities at track level or adjacent to an active CTA track is permitted only under slow zone and flagman protection during the periods of light ridership listed below, subject to approval by CTA Operations:

- Monday through Friday from 0900 to 1500 hours
- Monday through Thursday from 1900 hours to 0500 hours the following day
- Weekends from 1900 hours on Friday until 0500 hours on Monday morning

3-1.2 Construction activities at or above track level or next to an active right-of-way are not permitted during weekday "rush hours," typically from 0500 to 0900 hours and from 1500 to 1900 hours, Monday through Friday business days, except holidays.

3-1.3 Some CTA rail lines, as well as portions of other lines or branches are closed to passenger service at night or on weekends. These scheduled closures may offer contractors an opportunity to perform construction or other work on vacant track during those periods without interruption from passing trains and possibly with the 600-volt DC power removed. The latest revision of the CTA Bus and Rail Route Map shows the hours of service on each rail line or branch. The CTA Rail Operations department may approve the construction activities during the scheduled closures of the rail lines.

3-2 Communication Requirements

The CTA Control Center can be contacted seven days a week, 24 hours a day by CTA Radio (K347), Telephone: (312) 432-8030, or by CTA extensions 28030 or 28040.

3-2.1 The designated contractor's or consultant's representative in charge of each specific work site(s) shall be equipped with a cellular telephone to enable direct communications with the CTA Control Center, CTA safety inspector and 911 on a continuous seven-day, 24-hour-a-day basis. In the subway, the contractor personnel may need to have a flagman, operator or other CTA employee or an emergency phone to communicate with the Control Center in emergencies.

3-2.2 The contractor's personnel entering any work site on the right-of-way shall be accompanied by a CTA employee (flagman or construction inspector) equipped with a CTA radio. The CTA employee will notify the rail controller on the proper channel, providing all necessary information. The rail controller must broadcast this information to the rail operators on that specific line to operate according to established rules and procedures.

3-2.3 After the contractor's personnel clear the rail system, the CTA employee shall call the Control Center on the radio and report that all contractors' personnel are clear of the right-of-way, report the status of the rail tracks and other system components at the work site and the position of the slow zone signs.

3-2.4 Whenever the CTA flagman, safety or construction inspector or CTA Rail Operations management notifies the contractor of any deficiencies or unsafe conditions at the work site, the contractor's representative shall take immediate corrective action.

3-2.5 The designated contractor's representative shall promptly notify the Control Center of any hazards, safety deficiencies, emergencies or other needs for assistance (e.g., medical) at the work site(s).

3-3 Entering the Right-Of-Way

3-3.1 **No one is permitted to enter or work on the CTA right-of-way (including CTA employees) without first notifying and receiving approval from the CTA Control Center.**

3-3.2 The contractor's personnel must be assisted by a CTA (flagman, rail supervisor or construction inspector), equipped with radio communication with CTA's Control Center, when entering the right-of-way.

3-3.3 Before entering the right-of-way, the CTA employee shall request specific authorization using a CTA radio from the rail controller for that specific rail line according to SOP #8130, "Safety on Rapid Transit Tracks" (see Attachment 3). The CTA employee shall identify himself or herself, identify the number of people entering the right-of-way, identify the work location, direction of traffic, the planned work starting time, the estimated duration of work on, above or adjacent to the right-of-way.

3-3.4 No one is permitted to enter or work on, above or adjacent to track level during rush hours, Monday through Friday from 0500 hours to 0900 hours and from 1500 hours to 1900 hours. Access during these periods is permitted only if properly barricaded in compliance with section 4.5.3 of this manual or for emergencies.

3-4 Slow Zones

3-4.1 A slow zone is a section of track, marked with warning signs and lights, through which trains operate at reduced speed. When necessary, if the integrity of the right-of-way is degraded, a slow zone is setup to protect personnel performing work and their equipment in the work area from passing trains.

3-4.2 To avoid unreasonable delays to the riders, CTA Rail Operations and the project manager will approve the number, length and schedule for slow zones on each route.

3-4.3 Temporary track flagging work zones can only be mobilized, utilized and demobilized in non-rush hour time periods and no more than one track flagging operation zone will be permitted at any given time. The contractor shall be responsible to furnish and install the required slow zone signage and equipment. A track flagging operation zone is defined as a contiguous work zone, of no more than 600 feet in length, regardless of the number of tracks fouled.

3-4.4 The contractor, under the supervision of the construction inspector is responsible for installing, moving slow zone signs along the right-of-way as work progresses and for repositioning or removing all slow zone warning signs and lights daily or as required throughout the project. The CTA flagman will verify that the slow zone signs are installed according to the SOP.

3-4.5 The contractor is responsible for maintaining the slow zone warning lights and signs, including the purchase and replacement of batteries. The contractor shall return all issued slow zone

warning signs and lights to CTA in good condition at the completion of the project. Any costs required to replace or repair issued slow zone warning signs or lights shall be deducted from payments owed to the contractor.

3-4.6 Slow zone operations and the placement of warning signs and lights shall conform to CTA SOP #8130, "Safety on Rapid Transit Tracks" and SOP #7041, "Slow Zones" (see Attachments 3 and 4).

3-5 Flagman Protection

3-5.1 Whenever a contractor is working on, over or in close proximity to an operational rail right-of-way, a slow zone with flagman protection is required to facilitate safe and continuous train operations. The CTA flagman is dispatched to protect contractor personnel, CTA employees, customers, the public and property in the vicinity of the work site in accordance with CTA SOP #7041, "Slow Zones" (see Attachment 4).

3-5.2 The contractor shall provide the CTA with a written request for flagmen and other personnel at least 48 hours (two normal working days and before noon) prior to the date time of the work will be performed and the CTA personnel are requested.

3-5.3 The Rail Operations division will make every effort to provide flagging personnel to the contractor consistent with section 3-4.2. The CTA construction inspector shall verify that the construction work being performed requires flagman protection (See CTA Flagman Requirements Manual).

3-5.4 The contract specification includes the circumstances when the contractor must utilize the flagmen or other CTA personnel (e.g. switchman, towermen). In addition, the contractor is required to request flagmen or other CTA operating (e.g. switchman, towermen) and maintenance (e.g. electrician) personnel anytime when the construction inspector determines that is necessary to ensure safe train movement during a construction or engineering project.

3-5.5 CTA flagmen are responsible for ensuring that train traffic proceeds in a safe manner while work is in progress.

3-5.6 The provision of CTA flagging personnel and any other safety precautions taken by the Authority shall not relieve the contractor of any liability for death, injury or property damage arising in connection with the construction operations.

3-5.7 The CTA flagman is required to wear a safety vest and to bring to the work site an operable air horn with spare canisters, a red signal flag, a portable track trip device and a CTA communications radio. In low visibility areas and during night operations, CTA flagman shall also bring a flashlight to the work site as required in CTA SOP #7037, "Flagging on the Right-of-Way" (see Attachment 1).

3-5.8 The contractor shall conduct a site briefing for the CTA flagman before the commencement of work to ensure that the flagman knows and thoroughly understands any signals the contractor will use (e.g., to indicate that the right-of-way is clear for train traffic). This site briefing will prevent any potential miscommunication between the flagman and the contractor.
The contractor shall identify one work crew leader at the work site assigned to communicate with the flagman.

3-5.9 By labor contract, CTA flagging personnel are entitled to a 30-minute break after a continuous 5-1/2 hour work period, including report and travel time. The 5-1/2 hour period begins when the

person reports to work at his or her home terminal. Additionally, flagging personnel are entitled to occasional personal breaks (to use the washroom facilities) during the normal course of work. When flagging personnel leave the work site, work must cease unless a provision is made for a relief flagger. The contractor shall coordinate the project work schedule with the flagging personnel break periods.

3-5.10 The CTA construction inspector or a CTA Rail Operations representative will position each flagman initially; about 200 feet in advance of the work area according to SOP #7041, “Slow Zones” (see Attachment 4).

3-5.11 The flagman will signal (flag) oncoming trains to stop at the flag (see SOP #7041, “Slow Zones”). The flagman shall have the portable track trip device installed on the running rail opposite the motorcab (when facing in the direction of travel), directly across the track from the “Begin Slow Zone/6 mph” sign in order to stop any train.

3-5.12 When a train approaches the “Slow Zone 600 ft Ahead” sign, the flagman shall sound one long blast on his air horn to warn the work crew that a train is approaching the work area.

3-5.13 The contractor shall promptly interrupt construction activities, secure the area for train movement and clear all personnel, tools and material away from the track to allow safe train passage. Under no circumstances shall the contractor delay any train for more than two minutes after that train arrives at the work site. Failure to comply with every aspect of this requirement may result in immediate discontinuance of work at the site.

3-5.14 After the contractor has issued an "all clear" signal to the flagman, indicating that the track area has been cleared, the flagman removes the portable track trip staff and signals (showing the trip staff) the operator of the waiting train to proceed slowly (6 mph) through the work site. The operator acknowledges the “proceed” signal by two short sounds of the train horn.

3-5.15 If, for any reason, the train fails to acknowledge the flagman's signal to stop, the flagman will sound continuous short blasts on the air horn to signal the work crew to move quickly but safely out of the path of the train.

3-5.16 When the construction activity interferes with two-way train traffic or work is such that it requires more flagmen, the CTA will assign the necessary number of flagmen (See CTA Flagman Requirements Manual) or, in the case of manpower shortage, the work must be postponed until the prescribed number of flagman can be provided.

3-5.17 In areas of limited visibility or sections of curved track, an additional flagman shall be positioned between the primary flagman and the work crew, if required. If necessary, the second flagman will also use a portable track trip device to stop approaching trains. The “CTA Flagman Requirements Manual” provides guidelines for the coverage of flagmen assignments.

3-5.18 In an emergency or serious accident, the contractor shall direct the CTA flagman to notify the Control Center, by radio, and request immediate traction power removal to ensure withholding of all train movements in the area and to request any emergency assistance that is required (e.g., ambulance, police).

3-5.19 If the contractor, CTA construction or safety inspector believes that the flagman is unable to perform his or her duties responsibly, work shall be stopped immediately, ensure that the right-of-way is safe for train operations, and the work crew shall exit, without delay, the right-of-way.

The contractor must provide a written report to the construction inspector prior to the end of the workday. The Control Center shall be notified and a new flagman requested. When the new CTA flagman arrives at the work site, the work crew may re-enter the right-of-way and resume work only after the contractor completes the site briefing with the new flagman. All employees of the contractor and subcontractors must report any actions of perceived CTA employee misconduct, or if any CTA employee does not provide a full level of cooperation in support of the contract immediately to the CTA's Control Center and the CTA Rail Operations route manager. Within 24 hours of alleged incident, provide written report to the CTA project manager including a detailed explanation of the incident, employee badge numbers, location of incident, etc. Failure to make the proper notification in writing may adversely affect any claim the contractor may file with respect to CTA employee performance or lack thereof.

3-5.20 The contractor personnel (crew leader) cannot assume the duties or the responsibilities of a flagman, except in the case of an extreme emergency.

3-6 Track Access Occurrences

3-6.1 As much construction work as possible should be performed in slow zones under flagging protection. During certain light passenger traffic periods on some rail lines when completion of work tasks is critical to the project, it is possible for the CTA to operate trains on a single track. Generally, single-tracks are permitted only to enable the completion of construction tasks which cannot be interrupted (e.g., removing an entire section of right-of-way).

In single-track operations, passenger service trains are re-routed between adjacent crossovers as required to operate train service past the work site in both directions on the same track. The remaining track is inactive, leaving it available for continuous construction work. The 600-volt DC traction power may be removed from the out-of-service track to further facilitate work.

The CTA can operate trains on a single track only on certain lines and with the proper notification (21 days advance notice) of the CTA construction inspector and with approval of Rail Operations.

3-6.2 Track access occurrences may be provided to the contractor for work on the CTA right-of-way. In that event, the entire system must be fully operational when the tracks are put back into service after a track access occurrence. The track where work was conducted must be returned to CTA in revenue condition; all stations must be open, fully functional and properly cleaned in both directions. The contractor shall be immediately available with sufficient staff for up to one hour after revenue operation begins to ensure that all systems are functioning properly.

3-6.3 The contractor shall allow enough time prior to putting the tracks back into service to make sure the line can be fully operational. A test train shall be required after any track replacement, signal modification or any construction activity, determined by the engineer, to require a test train. The scheduling of test trains must include travel time to and from the location being tested. Additional time should also be allowed for any possible remedial work required before the system can be made fully operational.

3-6.4 All components of the system, including, but not limited to, tracks, signals, stations, entrances, etc. must be fully and properly operational prior to putting the tracks and facilities back into service. Any facilities under demolition or construction and any temporary facilities must be safe and secure so they do not impact revenue service operations.

3-6.5 The CTA reserves the right to deny the contractor's request for a single-track if necessary to meet passenger service requirements. Typical reasons for denial may include increased ridership due to major events (e.g., festivals, sporting events, concerts), inadequate labor force, or conflict with other service alterations on the CTA system.

3-6.6 The contractor shall request approval from the CTA project manager at least 21 calendar days before the proposed starting date of construction activity that requires single-track train operations. The contractor must receive the approval of the CTA inspector and Rail Operations before any single-track train operations can begin.

3-6.7 The contractor shall confine all work to be performed within the single track. The work activity must not affect the active revenue service tracks.

3-6.8 In case of an emergency, the CTA reserves the right to cancel a single-track operation at any time. If the single track is cancelled, the contractor must take the steps necessary to return the track to revenue service immediately.

3-6.9 Before the end of the single-track operation period, the contractor shall suspend construction activities and restore the inactive track to full operating condition in sufficient time to operate any required test trains (see Section 2-3.4) and resume revenue service no later than the end of the allowable hours of construction.

3-6.10 When movement of track geometry testing cars, work or testing train and track maintenance equipment to and from the single-track location is necessary, the movement shall be governed by the CTA Rail System Rule Book, SOP #8137, "Moving railborne track maintenance equipment" and any requirements included in the service bulletin issued by Rail Operations for that "unscheduled train."

3-6.11 All railborne equipment must be approved by CTA Rail Operations. No gasoline powered railborne equipment is allowed on an active and energized CTA right-of-way.

Chapter 4: General Safety Requirements for Contractors, Subcontractors, Consultants

4-1 Personal Protective Equipment and Apparel

4-1.1 Contractor personnel shall wear a CTA-approved high visibility safety vest (furnished by the contractor) at all times while on the CTA right-of-way. The safety vest shall have CTA-approved reflective stripes on both the front and back.

4-1.2 Contractor personnel shall wear Class B (non-conductive) ANSI approved hard hats during all work activities on, under, above or adjacent to the CTA right-of-way.

4-1.3 Contractor personnel shall wear suitable (natural fiber) work clothing. Short or cut off pants, sleeveless shirts or halter-tops are not permitted. Loose, ill-fitted, unfastened and unbuttoned clothing and belts with sashes or hanging pendants shall not be worn.

4-1.4 Contractor personnel shall wear suitable work shoes with a defined heel and non-slip soles. Because of the electrified third rail, steel toes or metal cleats on the sole or heel of shoes are prohibited. Shoelaces are to be kept short so they do not pose a tripping hazard. Athletic

shoes, sandals, open-toed shoes, moccasins or shoes with heels higher than one inch are not permitted.

4-1.5 Contractor personnel shall wear eye protection for all welding, cutting and specialized work activities as indicated in the contractor's Safety Management Program (SMP) and any other protective equipment in accordance with the applicable OSHA regulations. Contact lenses are not permitted.

4-1.6 Contractor personnel shall have a non-metallic, working flashlight after dark or when working in the subway.

4-1.7 The contractor shall maintain a first aid kit for employees at the work site.

4-2 Ongoing Safety Indoctrination

4-2.1 The contractor is required to provide their personnel with a project safety orientation and training session, which addresses general safety issues, and project-phase specific safety issues integrated in the Safe Work Plans (SWP) for this contract. The FTA Alcohol/Drug Rule shall be included in this safety orientation.

4-2.2 Every day the contractor shall instruct his or her employees working within the right-of-way about the danger presented by working near an uncovered electric third rail (600-volt DC) and other energized facilities, safe clearance from passing or standing trains, etc., and all reasonable precautions to protect the personnel in this environment.

4-2.3 On a weekly basis, the contractor safety representative (CSR) shall conduct, and the safety inspector shall attend, a Just in Time Training meeting with all employees assigned to a work site. The CSR shall include a step-by-step hazard analysis on the work scheduled for the following week, review all applicable Material Safety Data Sheet (MSDS) for the chemicals being used, and reiterate the hazard control practices and the importance of using the required Personal Protective Equipment and emergency response.

4-2.4 The CSR shall discuss at weekly Just in Time Training meeting(s) all new CTA service bulletins related to passenger service adjustments affecting that specific work site.

4-2.5 Contractor personnel shall report to work physically and mentally prepared to follow all safety rules included in this Safety Manual and other requirements of applicable federal, state and local safety and health laws, statutes and regulations.

4-2.6 Contractor personnel entering and working on the CTA right-of-way shall comply with FTA Substance Abuse-Free Environment Program (SAFE) (see Attachment 14). The use or possession of liquor or a narcotic of any kind on CTA property by contractor personnel while on duty or reporting for duty under the influence of it is strictly forbidden.

4-3 Safety on Rapid Transit Tracks

4-3.1 Contractor personnel shall wear the approved safety vest and proper safety equipment when working on, above or adjacent to the right-of-way and must observe the railroad basic safety rules:

- Never enter the CTA right-of-way without notifying, by radio, the rail controller for that specific rail line (see Section 3-5)
- Stop and look in both directions before crossing a track. Remain in a clear and unobstructed view and face an approaching train
- Expect trains to operate in either direction, on any track, at any time
- Step over rails, never step on any rail
- Do not allow any part of the body, any article of clothing or tools to contact the third rail or trolley blocks of rapid transit cars
- Consider the third rail to be energized at all times
- Use the footwalk, unless work requires you to walk between tracks
- Watch for moving switch points
- Stand clear of the car overhang on curves
- Stand clear of areas of no clearances
- Stand and face an approaching train and remain stationary until the entire train has passed
- Never jump from a station platform, footwalk or rapid transit car to track level
- Never run on the footwalk or at track level
- Alert all other persons in the area concerning the presence of a train

4-3.2 Contractor personnel entering the CTA right-of-way shall consider all traction power third rails and electrical feeder cables to be energized unless removal of power and proper lockout has been confirmed (by the power controller) and verified with test equipment. The construction inspector shall designate CTA personnel (electricians) for this purpose and shall ensure that such personnel are known to the contractor.

In the absence of such verification, the contractor shall maintain a ten-foot clearance from the traction power contact rail third rail and cables. If the work dictates that this clearance zone cannot be maintained, the contractor shall install physical barriers, use an approved cover for energized third rail, cable, etc., or take other safety precautions as required to ensure an adequate level of safety.

4-3.3 The contractor shall caution all employees about the presence of 600-volt DC on certain portions of the railcar undercarriage and on both sides of each train on the trolley blocks and trolley shoes (current collectors). The contractor shall take all necessary precautions to prevent any contact of personnel body parts or tools with the electrical system of an operating train.

4-3.4 Whenever the disconnection of the third rail or other energized facilities in the work area will not interfere with train operation (local isolation switches) and such disconnection is approved by Rail Operations, the contractor shall be responsible for arranging with the CTA Control Center to set up such isolation before the commencement of work. Certain portions of the work shall be performed on sections of track where rail service is suspended in order to facilitate the work. For any work occurring within a section of track to be taken out of service, the contractor shall confirm with the Authority that track within the work limits has been taken out of service and the third rail de-energized, as required, prior to beginning the work.

4-3.5 If disconnection of traction power is not feasible, the contractor shall furnish approved insulating covers or hoods to cover energized third rail, cable, etc. to protect personnel working in close proximity to energized facilities.

4-3.6 At the beginning of every shift on every day at every work site where energized third rail or feeders exist, the contractor shall instruct his or her employees about the location of the local power disconnect switches for that power section and the method of emergency disconnection available at or near to the work site.

4-3.7 Contractor personnel are not permitted to walk, step onto, rest feet on or sit on railheads, frogs, switches, guardrails, pipe, interlocking or connecting apparatus, cable boxes, etc., except when necessary for the performance of a specific required task. When crossing any of these facilities, the contractor shall take great care when stepping over equipment.

4-3.8 Practical jokes or horseplay by contractor personnel is a serious hindrance to personal safety during this type of work and shall not be permitted.

4-3.9 CTA safety practice prohibits equipment or personnel from being suspended over the right-of-way while trains are passing or standing underneath.

4-3.10 When signaled by the flagman's air horn, the contractor shall stop all activities, clear the track and, if possible, move to a location at least seven feet, two inches away from the center of the track occupied by the approaching train (outside of "No clearance beyond this point" and curve area).

When a full seven feet, two inch clearance cannot be maintained, contractor personnel shall move six foot, one inch away from the center of the track, keep their hands, feet, and loose clothing close to their body and away from the passing train. Contractor personnel shall face the oncoming train until it leaves the work site.

The contractor is responsible for ensuring that the track work site is cleared in a timely and safe fashion before notifying the flagman that it is safe to allow the train to proceed into and through the work zone.

4-4 Operation of Electrical Facilities

4-4.1 The person requesting removal of traction power due to an emergency (operator, flagman, CTA emergency K202, CPD, CFD or a contractor representative) is the only authorized person (under lockout/tagout procedure) to request restoration of power according to CTA SOP #7049, "When to Remove 600 Volt Power," (see Attachment 6). The person requesting "power off" must remain in the area (unless relieved by the proper authority) and request "power on" as soon as possible.

4-4.2 If the traction power needs to be removed locally from the Traction Power Sectionalizing Boxes, these boxes must be de-energized before the switches are operated. Only authorized CTA personnel (electrician) may open boxes, operate switches and lockout/tagout these boxes.
The CTA intends to issue Power & Way service bulletins to supplement CTA rail service bulletins. The Power & Way service bulletins are intended to provide procedural guidelines for safely removing and restoring the CTA's Power & Way systems (primarily traction power & signal) within the limits defined by the contract and contractors specific track outage plan(s). The contractor will follow procedures defined within the contract documents for requesting track access occurrences.

4-4.3 If work is required inside a CTA substation, the contractor shall notify the CTA inspector and CTA project manager and obtain a substation property pass. A CTA substation attendant will meet the contractor at the substation. The contractor shall not enter a CTA substation, close any switches, or open any panels without a CTA substation attendant. The CTA substation attendant will perform these tasks, if necessary.

If work inside a substation can be expected to impact train operations, the contractor shall notify and request approval of the project manager and CTA Rail Operations at least 21 calendar days before the proposed starting date of the work.

4-5 Protection of Employees, Passengers, Trains and Facilities

4-5.1 The contractor shall take all necessary preventive measures and precautions to protect contractor employees, CTA employees and passengers, the public, property and adjacent areas from any possible injury or harmful exposure that could result from dust (lead-based paint or asbestos), debris or other contaminants created during the project activity.

4-5.2 When work is performed on or next to the track area, the contractor shall maintain the clearance envelope specified in the current CTA Design Criteria Manual-Clearance Diagram at Boarding Areas (stations) and in Clearance Diagram at Non-Boarding Areas (along the right-of-way). No exposed construction equipment, temporary wiring, piping, or other physical obstacles shall be installed or stationed in the public areas which conflict with customer safety.

4-5.3 When the construction work is performed adjacent to an active track and the work does not involve the track or the third rail, the contractor can provide an uninterrupted physical barrier (barricade), and the right-of-way allows for at least six feet high (above track or platform level) to separate the work area from operating track(s). With the barrier in place, work on the other side of the barrier may be permitted at any time without a CTA flagman and slow zone protection, provided that a rail service bulletin is issued and approved.

Such temporary barriers shall be installed as far from the operating track(s) as possible, but no closer than seven feet, two inches from the centerline of the nearest operating track. For a maximum length of 100 feet, the temporary barriers can be installed at six feet, one inch distance from the centerline of the nearest operating track if approved by CTA Safety and CTA Rail Operations. “No Clearance Beyond this Point” signs must be installed on the trackside at a height of five feet from the top of rail or platform and placed at the ends and every 25 feet on the temporary barrier. The project manager must get the approval from the CTA Rail Operations division for all the materials, location, construction and installation of the temporary barrier and the work procedures adjacent to the barrier.

4-5.4 When conducting construction activities, the contractor shall take special care to avoid causing damage, settlement or displacement of any structures, tracks or any portion thereof or interrupt the continuity of train service. Any damage to CTA facilities resulting from the contractor's activities shall be promptly replaced or repaired by the contractor to the satisfaction of the CTA project manager without additional cost to the CTA and liquidated damages may be assessed. The contractor shall, at all times, take special care to conduct operations over, on, under, adjacent to, or adjoining, the CTA right-of-way in such a manner as not to cause damage, settlement or displacement of any structures, tracks or any portion thereof. The contractor shall suspend such work until reasonable remedial measures, satisfactory to the Authority, have been taken.

The Authority shall have the right to perform any work it deems to be of an emergency nature and necessary to permit normal train operations during construction operations by the contractor. The cost of such service or emergency work provided by the Authority shall be borne by the contractor.

4-5.5 The contractor shall provide adequate protection for all electrical, signal and communication equipment from dust, debris, water, etc., through the introduction of rubber, plastic, cloth,

wood or other barriers. This protection applies to all CTA equipment located in substations, elevated structure, subways, shops, etc.

4-5.6 The contractor shall ensure that all temporary electrical (conduits, cords) and construction equipment (scaffolding, ladders) is installed and used in a manner that would not present any safety hazard to CTA employees and the public. Any additional lighting, heating or ventilation that becomes necessary is the responsibility of the contractor.

4-5.7 The contractor shall secure any loose containers, tools or other objects that could be thrown on the tracks or dislocated by the vibrations generated by a moving train. This requirement applies to all locations on the CTA right-of-way, including station platforms.

4-5.8 Whenever permanent fence, grills, grates or access panels are removed within the rail system, the CTA Control Center, the safety and construction inspector shall be notified.

4-5.9 Whenever a contractor must remove a permanent barrier, fencing, grills, grates or access panels in order to perform a required work activity, the contractor shall be responsible for properly maintaining, protecting and securing that opening throughout the work area to the standard of care provided by the permanent facility.

4-5.10 Immediately upon completion of work, the permanent barrier shall be fully restored. If the duration of work is longer than one work shift, temporary barriers/barricades that provide physical protection equivalent to the permanent barrier, shall be built. Whenever temporary barriers/barricades are erected within the rail system, the CTA Control Center, and the safety and construction inspectors shall be notified.

4-5.11 Whenever work is done within City of Chicago, suburban or State of Illinois roadways and street property, the contractor is responsible for providing flagging personnel as required to maintain highway or road traffic operations. The contractor shall also provide all street barricades, barriers and signs that are required to maintain a safe and orderly traffic flow and meet the requirements of the Manual on Uniform Traffic Control Devices. The contractor shall also provide adequate warning in advance of such work sites to prevent any conditions or situations that could jeopardize the safety of workers at the site or the public. The contractor is required to maintain all equipment and signs in good working condition at all times.

4-5.12 Whenever work activities demanding road closure must be performed on the CTA's elevated structure or a bridge above a public roadway, the contractor shall obtain all required lane closure permits from the applicable municipality, and shall notify the CTA project manager and construction inspector at least 21 days in advance of the lane closure. All lane closures shall conform to applicable IDOT and local municipality rules for temporary lane closures.

Chapter 5: Site-Specific Safety Requirements

5-1 Subway Sites

5-1.1 Due to the inherent danger associated with working in the confined area of a subway tunnel, the contractor shall have a fire control plan in effect at all times.

5-1.2 Before each shift on every day at every work site in the subway, the contractor shall conduct a briefing to review fire safety. This briefing shall include, but not be limited to, a review of the

locations of all emergency equipment (e.g., phones, fire extinguishers), emergency exits layout and associated instructions. The contractor shall specifically identify the locations and distance to the nearest available emergency exit in each direction from the work site.

5-1.3 The contractor shall not bring any toxic, flammable, strong smelling or other potentially hazardous materials or chemicals into the subway or any other enclosed area or room.

5-1.4 Electric power tools and equipment must be used when performing work in the subway.

5-1.5 Gasoline or gasoline-powered engine tools are not permitted in the subway due to the presence of 600-volts DC third rail and the potential for ignition and explosion.

5-1.6 Tools powered by diesel combustion engines may be used on a limited basis in the subway subject to approval by safety inspector. The diesel engine must be equipped with a catalytic converter and proper ventilation needs to be provided to exhaust the smoke from the subway.

5-1.7 Combustible/flammable materials including oxygen/acetylene cylinders shall not be stored in the subway at any time. The contractor shall not bring any more than a one-half workday's supply of combustible (e.g., paint, lubricants) or flammable liquids (e.g., diesel, solvent) to a subway work site. Combustible/flammable materials shall be transported in approved/labeled safety containers. The contractor shall provide sufficient fire extinguishers and trained personnel to suppress the simultaneous combustion of the maximum quantity of combustible liquids maintained at the work site.

5-1.8 Combustible/flammable waste materials or oil soaked rags shall be secured in approved safety containers and must be removed from the subway at the end of each work shift. Neither safety containers nor other materials shall be placed and stored on the emergency evacuation footwalk or within the emergency exit passageway.

5-1.9 The contractor shall review the CTA standard showing the clearance envelope required for subway trains in the tunnels and shall maintain these clearances at all times.

5-1.10 The contractor shall secure any loose containers or other objects which could be thrown on the tracks or drawn into the path of a moving train by the created suction. Empty drums or barrels are considered to be loose containers and shall be secured within a designated area. This requirement applies to all locations on the CTA rail system subways including station platforms.

5-1.11 Contractor personnel and flagmen are required to use flashlights when signaling trains in subways. The contractor shall conduct a safety briefing for contractor personnel to review proper signaling procedure prior to any work in the subway.

5-1.12 The contractor shall use only non-conductive flashlights while working on the CTA rail system.

5-1.13 Due to space constraints, the contractor shall specifically identify where contractor personnel are to relocate when signaled to clear the track and permit safe passage of train through the work area.

5-1.14 No rooms in the subways shall be opened, entered or used without approval from the construction inspector and the CTA Control Center.

5-1.15 Subway track areas are to be accessed using walkway ladders provided at designated locations along the high footwalk. Jumping from or climbing up the footwalk is not permitted.

5-1.16 Subway lighting is designed for emergency evacuation and may not be adequate for certain types of work to be performed during the project. The contractor may provide supplemental lighting at their own expense, as long as the type, power supply, attachment, placement and orientation (away from the motorcab) of the light fixtures are approved in advance by the CTA inspector and Rail Operations.

5-2 Elevated Structure and Bridges

5-2.1 The contractor's Safe Work Plan shall list all required Personal Protective Equipment, including the proper workers' health and safety procedures to be followed when working on steel structures coated with lead-based paint.

5-2.2 The contractor shall temporarily relocate and provide adequate protection for all messengered (electrical, communication or fiber optic) cable. The protection method and materials for the relocated cable shall be approved in advance by the CTA project manager.

5-2.3 When contractor personnel are working on the elevated structure from underneath and could reach above track level with their bodies or tools, a track level flagman shall be employed to support this activity and a slow zone must be set up for protection.

5-2.4 The contractor shall carefully consider the weather factors (e.g., ice, rain, snow, heat) when determining whether work activities should be undertaken on each day or shift. The final decision shall be made after consulting with the CTA construction inspector and with CTA Rail Operations.

5-2.5 The contractor shall review the CTA standard showing the clearance envelope required for CTA trains and shall maintain these clearances at all times. Contractor personnel shall exercise extreme caution on elevated track sections, always maximizing the distance to the edge of the structure.

5-2.6 Whenever contractor personnel are walking along the track, they shall remain on the footwalk. When contractor personnel must leave the footwalk, they shall exercise extreme caution to avoid tripping, falling, or losing their balance and coming in contact with the third rail. When contractor employees are walking on an elevated structure or a bridge's footwalk, they shall watch for wood boards that appear to be rotten or broken and for fiberglass panels that appear to be detached and avoid stepping on them.

5-2.7 Many elevated track footwalk sections are not equipped with guardrails or equivalent means of fall protection. Whenever the contractor is working along a section of track on the elevated structure, at a height of six feet or more, an effective personal fall protection method shall be employed (temporary handrail, individual fall protection, personnel nets, catch platforms, etc.).

5-2.8 Whenever the contractor is working on an active right-of-way in proximity to the third rail and moving trains, the use of a safety harness/lanyards as fall protection equipment shall not be utilized. The contractor shall use temporary handrail, scaffolding, decking or safety nets as fall protection.

Safety nets shall be provided when workplaces are more than 25 feet above the ground or water surface, or other surface where the use of ladders, scaffolds, catch platforms, temporary floors, safety lines, or safety harness is impractical. When safety net protection is used, the construction activity shall not be undertaken until the net is in place and has been tested.

5-2.9 Whenever work activities must be performed on structural members or on elevated railway tracks above a street or a right-of-way, the contractor shall install debris nets under the structure or close the street.

5-2.10 Within the designated work area, the contractor shall secure any loose materials or other objects that could fall to the ground or shift into the path of a train due to vibrations from passing trains.

5-2.11 No flammable or combustible materials or debris shall be stored under the elevated structure without approval from the construction or safety inspector. Any construction staging or storage yard under the elevated structure must be enclosed at all times with a fence with a minimum height of six feet.

5-2.12 Operators of cranes or other aerial lift equipment shall be licensed and trained in the proper and safe use of that equipment by the contractor (or the subcontractor providing the lift equipment). The contractor shall maintain training records or comparable documentation of training for the crane and lift operators at the work site and provide them to the CTA safety and construction inspector upon request.

5-2.13 Only non-conductive ladders shall be used while working on or under elevated structure. The construction, installation and use of ladders shall conform to the latest edition of ANSI A14.1, "Safety Codes for Portable Wood/Fiberglass Ladders."

5-3 Ballasted Track on Embankment, at Grade or in Expressway Median

5-3.1 The contractor shall temporarily relocate and provide adequate protection for all messengered (electrical, communication or fiber optic) cable installed above the embankment retaining wall and for all buried cable. The method and protection materials for the relocated cable shall be approved in advance by the CTA project manager.

5-3.2 The contractor shall carefully consider the weather factors (e.g., ice, rain, snow, heat) when determining whether work activities should be undertaken on each day or shift. The final decision shall be made after consulting with CTA construction inspector and with CTA Rail Operations.

The contractor shall use caution when walking on slippery surfaces near an operating track, the third rail , above or adjacent to the edge of a retaining wall and an effective personal fall protection method shall be employed (individual fall protection, personnel nets, catch platforms, etc.).

Chapter 6: Special Safety Requirements

6-1 Fire Safety

6-1.1 The contractor safety representative shall instruct the contractor personnel about all applicable fire safety regulations (Chicago/Local Building Code, NFPA Standards) associated with working on, adjacent or in close proximity to an operational CTA right-of-way. Contractor personnel shall comply with those regulations.

6-1.2 The contractor shall provide and use UL-approved safety cans for all flammable liquids with a flash point of 110 degrees Fahrenheit or below.

6-1.3 The contractor shall not maintain any more than one-half day's supply of combustible/flammable liquids at a work site. The contractor shall provide sufficient fire extinguishers to suppress the simultaneous combustion of the maximum quantity of combustible/flammable liquids that can be maintained at the work site. Whenever combustible liquids are present at a work site, the contractor shall provide sufficient personnel at the work site who are trained to use those extinguishers.

6-1.4 The contractor shall develop and implement a hot work procedure as part of Safe Work Plan. All welding and cutting apparatus, equipment and operations shall be in accordance with the requirements set forth in the current edition of ANSI Z49.1, “Safety in Welding and Cutting” standard.

6-1.5 Prior to welding, flame cutting, or other operations involving the use of open flames, arcs, or sparking devices, permission must be requested and granted by the CTA construction inspector. Portable welding screens and shields shall be used to protect other workers and the public in the immediate area.

6-1.6 Approved fire extinguishing equipment must be readily available at the location when welding and cutting is being carried out. When welding, cutting and heating is such that normal fire prevention precautions are not considered adequate, trained fire guards or fire watches shall be assigned and maintained for a minimum of 30 minutes following the completion of work.

6-2 Confined Space Area Activity

6-2.1 Work within confined spaces (e.g., manholes, ventilation shafts, areas of restricted accessibility or limited ventilation) requires special precautionary measures. If entry into a permit-required confined space is necessary, it shall be directly supervised by the contractor's qualified person (attendant). OSHA and CTA safety rules applicable to confined space entry shall apply.

6-2.2 The construction inspector shall provide the contractor with all available information about the particular CTA confined space (voltage ratings, asbestos, etc.). The contractor safety representative (CSR) shall authorize the plans to enter any permit-required confined space prior to entry.

6-2.3 Before entering the confined space, the contractor shall have issued emergency preparedness plans should the environmental conditions become inappropriate.

6-2.4 The air quality within the permit-required confined space shall be verified prior to entry and monitored during the work period by the contractor personnel working in the permit-required confined space.

6-2.5 A contractor's qualified person (attendant) shall remain outside of the confined space at the entry point and maintain constant communications with those inside the confined space.

6-2.6 In those instances, where electrical service is required in the confined space, low voltage (24 V) lighting or a ground fault circuit interrupter (GFCI) shall be used. If a GFCI is used, the unit must be outside and isolated from the confined space unit. Caution must be taken to ensure that the area is free of all electrical hazards.

6-3 Vermin Control

6-3.1 When the contractor is working in an area where vermin may exist, the contractor shall provide protection against the dangers associated with the vermin, including the following controls:

- Boots, gloves, or other Personal Protective Equipment as required
- Instruction in recognition and identification
- Repellents
- Communication for reporting of the location of nests

6-3.2 The contractor shall report to the CTA construction inspector any unsanitary conditions at the work site that have proliferated or could flourish insects or vermin.

Chapter 7: Security Requirements

7-1 Security Control

7-1.1 Site security and control: The contractor shall outline its plan for site security including prevention of unauthorized entry onto the project site and prevention of vandalism. The plan shall include all contractually-required security items. This plan shall include, when necessary: use of fencing, temporary enclosures, concrete barricades, surveillance cameras, signs, guard services and worker identification such as hats, shirts or vehicle stickers.

7-1.2 Post No Trespassing signs. This will also assist the police in cases where persons are arrested for unlawful entry.

7-1.3 The contractor shall provide for clearly-marked construction zones and transition zones, informing both contract workers and CTA employees upon entering construction areas and what Personal Protective Equipment is required.

7-1.4 The contractor shall prevent incidents within control and responsibility, effectively protecting CTA critical assets. Maintain on site, telephone numbers of emergency agencies and key project personnel.

7-1.5 The contractor shall prepare respond procedures to construction site incidents and accidents for the prevention, mitigation loss and protection of CTA and contractor employees and passengers from incident.

7-1.6 The contractor shall support emergency responders in incident response. Assess response readiness by conducting drills and exercises. Designate gathering areas in response to an incident.

7-1.7 The contractor shall design work to incorporate security features. Incorporate security principles into the design of new stations, systems, etc., including eliminating dead areas, providing adequate lighting, constructing gathering areas that are easy to monitor, facilitating ability for natural surveillance with lines-of-sight for CTA employees, installation of

communications equipment, such as payphones and access buttons, to provide access to assistance, using materials that allow for clear lines-of-sight, however, do not provide climbing access to other secured areas. (Do not disable pre-existing security equipment without checking with the CTA's Office of Security first.)

7-1.8 The contractor shall conduct system-wide security assessments to identify and eliminate or lessen potential security concerns during construction. Reviewing activities and new plans to determine how they impact the security for the areas as the work progresses.

7-1.9 The contractor shall communicate security concerns or incidents to the CTA.

7-1.10 The contractor shall promote security awareness to employees, including CTA employees who visit the work area.

7-1.11 The contractor shall report all incidents criminal in nature to the police and obtain a police report number. Also report all criminal incidents to the CTA project manager.

7-1.12 The contractor shall ensure that all equipment and facilities are properly secured at the end of each workday.

Chapter 8: Enforcement Of Safety Rules

8-1 Enforcement Of Safety Rules

8-1.1 The contractor safety representative is responsible for promoting safe work practices by contractor personnel. The contractor safety representative is also responsible for implementing the contractor's Safety Management Program (SMP) and enforcing the strict compliance of contractor (and subcontractor) personnel with the safety rules and procedures contained in or referenced in this Manual.

8-1.2 The safety inspector is the Authority's representative at the project (construction) site and is authorized and responsible for monitoring and auditing contractor work activities for strict compliance with the safety rules and procedures contained or referenced in this Manual.

To meet these responsibilities, the safety inspector shall have access to the project (construction) site at all times throughout the life of the project. The contractor is subject to unannounced field audits or inspections by the CTA safety inspector, construction inspector or management personnel from Rail Operations.

8-1.3 Whenever noncompliance with safety rules is found, the CTA safety or construction inspector or personnel from Rail Operations shall document that deficiency on a CTA Unusual Occurrence Report (see Attachment 9) or Safety Inspection Report, submit the original report to the contractor to take immediate corrective action, and submit copies to the project manager and to CTA System Safety. The safety inspector has final approval over the resolution and satisfactory closure of each deficiency.

8-1.4 If the CTA safety inspector determines that the contractor or contractor personnel have committed serious or repeated violations of the safety rules or procedures contained in or

referenced in this Manual or the contractor has failed to take prompt and decisive corrective action on safety deficiencies identified at the work site, the safety inspector shall have the power to terminate work by the contractor and direct the contractor to close and secure the work site.

8-1.5 The construction inspector is responsible for ensuring that any incidents or deficiencies involving CTA flagman at work sites are reported to the CTA Control Center immediately and after each work shift to Rail Operations division (see SOP #7037, “Flagging on the Right-of-Way”).

8-1.6 The construction inspector is responsible for defining the limits of the work zone. In addition, the construction inspector is responsible to notify immediately the Control Center whenever the work zone and the flagman are moved along the right-of-way.

8-1.7 The construction inspector is responsible for informing the project manager of any change or substitution of a material, equipment or procedure proposed by the contractor that was not included in original documentation of the project. The project manager shall determine whether the change or substitution introduces any safety hazard and shall inform the CTA construction inspector of any approved change or substitution.

Chapter 9: Reporting Procedures

9-1 Reporting Injuries and Requesting Assistance

9-1.1 The contractor shall be alert for dangerous conditions and unsafe work practices as part of their daily work routine. The contractor shall immediately address any conditions or practices that require correction to prevent injury or other harm.

If immediate corrective action by the contractor is not possible but the hazard warrants immediate attention, the contractor shall notify the CTA Control Center by telephone or by the CTA flagman or Combined Rail Operators (CRO) radio. In addition, the contractor shall complete a report documenting the dangerous condition and forward it promptly to the CTA safety inspector for appropriate action.

If an ambulance is necessary, the contractor shall call 911 or telephone the CTA Control Center to make the necessary arrangements for assistance. **The CTA Control Center can be contacted 24 hours/day by telephone: (312) 432-8030, or CTA phone extensions 28030 or 28040 or by CTA Radio: call # K347.**

9-1.2 In emergencies requiring removal of traction power, the CTA flagman or contractor's representative at the work site shall contact the CTA Control Center, specify the message "emergency power off,” the location, the type of emergency, the type of assistance required and the requester's name, phone/call number and badge number. The Control Center will remove traction power from that contact rail section (see CTA SOP #7049, “When to Remove 600 Volt Power” in Attachment 6).

9-1.3 For first aid injuries not requiring a physician's treatment, the contractor shall prepare a contractor's report of the injury and forward it to the CTAs inspector at the end of the shift or day. Injuries requiring in hospital or physician treatment or resulting in lost time shall be reported by the contractor immediately to the CTA safety inspector.

9-1.4 For all injuries, the contractor shall be responsible for conducting an accident investigation, issuing an accident investigation report, submitting a copy to the CTA safety inspector within 24 hours and processing the required paperwork to the insurance carrier.

9-1.5 The contractor shall also be responsible for completing and maintaining the OSHA 300 Log at the work site for the CTA safety inspector's review according to the contractor Safe Work Plan.

9-1.6 The contractor must report all rail "near misses" to the CTA safety inspector at the end of each shift or day for review and appropriate corrective action.

Title: **Flagging on the Right-of-Way**

Issued to: Flagman, Rail Service Supervisor (Operations), Track Gang Foreman (Maintenance)

Approved by: William R. Mo...
Chief Operating Officer

Supersedes: Flagging on the right-of-way, 7037 (12-04-00)

Any group of 3 or more people who will be on or near the right-of-way for more than one-half hour must operate under the protection of a flagman within an established slow zone. The department requesting a flagman is responsible for providing all sign/lamp assemblies and signpost mounting devices necessary for properly setting up the slow zone.

REPORTING FOR DUTY AT A TERMINAL (Operations Personnel)

Although no uniform is designated for flagmen, wear apparel that is both safe and appropriate for the job and weather.

- CTA-issued high-visibility safety vest
- Natural fiber outerwear, since synthetic fabrics may ignite from 600 volt arcing

Do **not** wear

- Shorts, cut-offs, sleeveless shirts, tank or halter tops
- Loose, ill-fitting, unfastened and/or unbuttoned clothing and belts with sashes or hanging pendants
- Long coats that may come in contact with third rail
- Clothing that restricts the wearer's vision (e.g. hoods) unless it can be worn in a way that vision remains unobstructed (e.g. with the hood down).

- Report to the clerk and transportation manager.

- Select, examine and test all necessary flagging equipment:

  - red flag (for use in daylight)
  - air horn with extra cannister
  - portable radio (previously issued)
  - portable track trip
  - flashlight (previously issued)
  - whistle (previously issued; as back-up if air horn malfunctions)
  - Dietz light (battery-operated flashing yellow light; for times or areas of limited visibility)

- When all equipment has been checked for proper operation, complete form *cta 3784 EQUIPMENT REPORT - FLAGMAN'S*, and leave the form with the clerk.

- Check the trainroom bulletin board and with the clerk for operating orders and/or bulletins regarding special train routings or other events scheduled at or affecting the flagging location. See the transportation manager for clarification.

- Obtain a time slip (form *cta 3533 TIME SLIP*) from the clerk.

- Perform a radio check (*10-40*). For specific instructions, refer to SOP 8200 *Radio Communication*.

- Proceed immediately via CTA service to the assigned work location.

  - Whenever possible, alight at the nearest station and walk to the work site.
  - Tools, supplies, materials and equipment that may be offensive to customers must not be transported on revenue service trains.
  - Flammable items must not be transported on revenue service trains.
  - Do not occupy seats to the exclusion of customers, nor occupy unused operating cabs in the train.
  - Do not occupy the head cab with the operator unless your specific job function requires it.
    - In cases where riding in the cab with the operator is necessary (e.g. to use the operator's radio), communicate the reason, starting point, ending point and run number to the controller and await verbal authority from the controller for the in-cab ride.

AT THE WORK LOCATION

Upon arrival at the work site, report to the work crew leader for instructions. The work crew leader is responsible for setting up the slow zone correctly, and has jurisdiction over the flagman.

- Call the controller to confirm arrival and to provide details regarding the exact location of the work crew, the number of people in the crew, any other work that is or will be performed near the work site, and the expected length of time the work crew will need a flagman.

- Check that the slow zone meets all the requirements of all applicable standard operating procedures.

> ***Note:*** ***If the slow zone has been set up improperly and the flagman and work crew leader cannot agree to correct it, the flagman will call the controller to request supervisory assistance. Once the controller has been notified:***
> - ***The workers and flagman must leave the right-of-way IMMEDIATELY.***
> - ***The workers and flagman must remain off of the tracks until a supervisor, instructor, or transportation manager arrives.***
> - ***The supervisor, instructor or transportation manager will evaluate the situation and make any necessary adjustments.***

INSTALLING THE PORTABLE TRACK TRIP

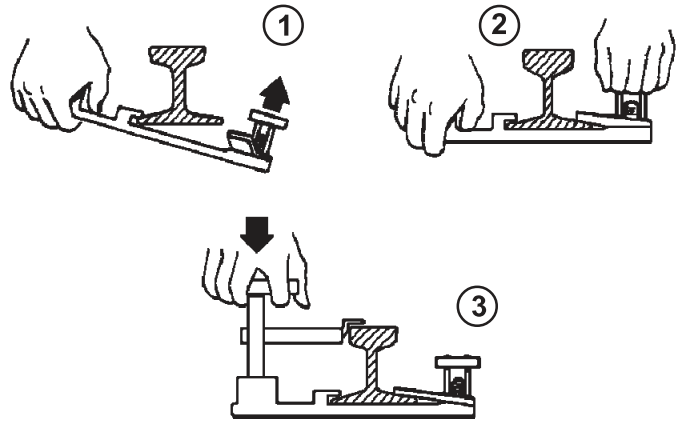
With the crew leader's assistance, select the location for installing the portable track trip.

- The location must provide secure footing.

- It must be directly across the track from the *Begin slow zone/6 mph* sign and both must be within 25 feet of the prescribed distance from the work area.

- At curves, hills, subway entrances, etc., provide rail operators with a view of the flagman's position that is as long and clear as allowable. Some circumstances will require two persons to *team flag* to provide ample warning.

Do not lean over the third rail or straddle it with your legs when installing the portable track trip base or when inserting the staff into the socket.



(1) Slide the portable track trip base under the running rail opposite the motor cab (when facing in the direction of travel). Move ballast as necessary to insert the base under the rail. The socket for the staff must be on the outside of the running rail.

(2) Mount the base onto the running rail by engaging the lip onto the outer base of the running rail. Secure the base by positioning the tightening plate (under the tightening handle) on top of the inner base of the running rail. Tighten the handle securely.

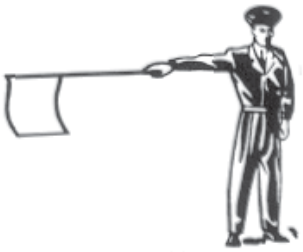
(3) Drop the staff into the socket with the tip of the trip resting on the running rail.

- When properly installed, the portable track trip, if run over, will bring the train to a stop. Also, if a train passes a trip, the wheels will permanently flatten the tip of the trip, providing proof of the train's having run the trip.

FLAGGING (Operations and Maintenance Personnel)

- Stand at track level next to the portable track trip, whenever clearance permits, even when flagging for workers on a platform or a work train.

- Stand in full view and face approaching trains.



- As a train approaches the *Slow zone 600 ft ahead* sign:

  - Sound one long blast on the air horn or whistle to warn workers.

  - At the same time, raise the red flag at arm's length in a *horizontal position* across the track being governed to signal the train to reduce speed.

- During periods of darkness and in the subway, motion is necessary to ensure recognition.

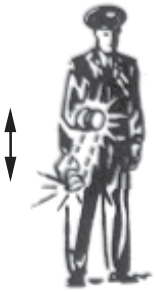


- To signal the train to stop, swing the flag or flashlight horizontally at a right angle to the track.
- To signal the train to make an emergency stop, violently swing the flag or flashlight across the track.



Note: In an emergency, if a red flag or flashlight is not available, signals may be given with the arm only.

- When the train stops:
  - Wait for the work crew foreman to signal that workers, tools, and equipment are in the clear and that the train may proceed.
  - Remove the track trip staff, face the train and show the trip staff to the operator of the train. During daylight, remove the red flag from the operator's view, then signal to proceed by hand signal.
  - After dark or in the subway, after showing the trip staff to the operator, signal to proceed by raising and lowering the flashlight vertically.
  - If a speed other than the standard restricted speed (6 mph) is desired, indicate this to the operator by voice or hand signal before giving the proceed signal.



Note: Never signal to proceed using the red flag or any red object.

- If two flagmen are assigned to the same location (one for each direction of train travel) and two trains arrive simultaneously, the loop-bound train receives priority.
  - The flagman guarding the loop-bound track must signal the other flagman to detain his/her train by momentarily holding the red flag or outstretched arm (during daylight) or flashlight (at night or in the subway) over the track of the train to be detained (outbound).
  - Allow the loop-bound train to proceed only after you have received a signal from the other flagman acknowledging that your signal was received.

- If it appears that an approaching train is not going to stop:
  - Leave the portable track trip in the tripping position.
  - Use short blasts of the air horn or blow the whistle to warn the workers.
  - Stand clear of the train.
  - Move the red flag or flashlight (at night or in the subway) *violently* across the track to attract the operator's attention. Continue blowing the air horn or whistle as a warning.
- If the train does not stop or stops after hitting the portable track trip:
  - Note the run and head car numbers of the train and immediately call the controller.
  - Report the incident, request any necessary assistance, and order a replacement portable track trip.
- Immediately report any violation of speed restrictions or failure to obey signals to the controller. Provide the exact time, location, direction, run number and head car number.
- **If members of a work crew fail to face passing trains or otherwise jeopardize their safety or the safety of others, or if they unnecessarily delay trains, notify the work crew leader. If violations continue, call the controller.**

WHEN WORK ASSIGNMENT IS COMPLETED (Operations personnel)

- When the work crew leader indicates that the work for the day is done, complete the time slip and have the work crew leader sign it.
- If a slow zone is to remain in place, notify the controller.
- Notify the controller when the right-of-way is clear.
- Return to the terminal and report to the clerk. Indicate on the time slip the actual time spent at the work location. Do not use the flagging trick's scheduled start and finish times.
  - Follow the same directives as for riding CTA service to the work location (page 2, top).
- Report any defective equipment or unusual incidents.
- Turn in flagging equipment and time slip to the clerk.

SAFETY IS PART OF THE JOB
Follow all CTA-established rules relating to safe operation, as well as those rules relating to use of tools, materials, equipment and personal safety in performance of these procedures.

Title: **Moving Railborne Track Maintenance Equipment**

Issued to: Transportation Manager, Rail Supervisor, Rail Instructor, Yardmaster

Approved by: Executive Vice President, Transit Operations; Executive Vice President, Construction, Engineering and Facilities

Supersedes: Moving railborne track maintenance equipment (02-16-92)

INTRODUCTION

Many pieces of track maintenance equipment have a short wheelbase and will not shunt track circuits consistently. These include, but are not limited to:

- Canron Tamper
- Jackson #1 Tamper
- Kershaw Tie Crane
- Kershaw Track Liner
- Tie Handler
- Fairmont Tamper Ballast Regulator
- Geismar Motor Cars
- Canron Undercutter
- Jackson Tie Remover and Inserter
- Kershaw Track Boom
- Marmon Snow Broom
- Racine E-Clip Machine
- Push Cars

Routes that normally are established as trains approach and crossing gates that lower automatically should not be expected to function for these vehicles. When any short-wheelbase equipment is moved, the following procedures ***must*** be followed.

GENERAL OPERATION PROCEDURES

- A Yardmaster, Rail Instructor, Rail Supervisor or Rail Transportation Manager (henceforth referred to as the *person in charge*) must supervise the movement of any track maintenance equipment.
- The operator of the equipment *must be qualified* to operate that specific piece of equipment.
- The *person in charge* must receive permission from Communication/Power Control before entering any mainline track.
- The *person in charge* must authorize the movement of track equipment through any yard, interlocking, grade crossing, turnout or crossover.
- The *person in charge*, or his designee, must ride the piece of track equipment.
- When several pieces of track equipment are being moved, an additional person with a radio must ride the last piece of equipment.
- Any trip that fails to clear the equipment must be pinned to prevent damage to the equipment.
- All pinned trips must be unpinned when the move is completed.

- When operating on an in-service track, the track maintenance equipment must be protected by Manual Block Operation. See ***Standard Operating Procedure 8198, Manual Block Operation.***

  - A supervisory employee, equipped with a two-way radio, ***must*** ride the first train operating behind the equipment.

  - This train can be either a work train, a buffer train or an in-service revenue train.

  - The *person in charge* on the track equipment must report his location and give the train following the equipment clearance to move up.

  - A distance of approximately one station must be maintained between the equipment and the train following it.

OPERATION IN YARDS

- All hand-throw switches, including spring-and-stay switches, must be prealigned. ***Track maintenance equipment must never trail through any switch that is not properly aligned.***

OPERATION THROUGH INTERLOCKINGS

The *person in charge* authorizes equipment to move through the interlocking, with tower assistance. If no towerman is on duty, the following procedures must be performed by the *person in charge* or his *designee*.

Track maintenance equipment may only indicate occupancy intermittently on a tower panel as the vehicle proceeds through track circuits. Therefore, at automatic interlockings that are activated by train approach, it *is* possible for a route request to occur and be activated while a piece of track maintenance equipment is moving through the interlocking. Consequently, it is necessary to take measures that will ensure that switches do not operate while movements of track maintenance equipment are in progress. The following actions ***must*** be taken.

- With a Towerman on duty or control panel available, or when using Power Operated Switch Panels,

  - The *person in charge or his designee* shall:

    - Explain to the Towerman/control panel operator the required move, in detail, and the problems that may be encountered when moving the track maintenance equipment through the interlocking.

    - Remind all personnel involved that track equipment may only indicate occupancy intermittently on the tower panel as the equipment proceeds through track circuits.

  - The Towerman/control panel operator shall:

    - Establish a route by using auxiliary switch levers, if provided, to preset all switches.

- After establishing a route, physically move away from the control panel a sufficient distance to prevent accidental operation of the auxiliary switch levers.
- Notify the *person in charge* that the route is established and locked in.

- Where no control panel is provided or when a wayside route selector is used
  - All switchpoints (both facing and trailing) must be properly aligned and wedged.
  - When the move is completed, all wedges must be removed, all pinned trips must be unpinned, and any trouble alarms must be reset.

OPERATION AT GRADE CROSSINGS

- Track and street gates shall be operated manually, even if they open or lower automatically.
- Grade crossings must be protected by a flagman.
- Once the automatic gate crossing signal light is illluminated (steady green), the *person in charge* may authorize equipment to move through the intersection.
- When the move is completed, restore track and street gates to automatic operation.

SAFETY IS PART OF THE JOB
Follow all CTA-established safety rules relating to use of tools, materials, equipment and personal safety in perfomance of these procedures.

cta	**Transit Operations** Standard Operating Procedure	**Publication Number:** **8130 (07-12-09)**	**Page 1 of 6**

Title: **Safety on Rapid Transit Tracks**

Issued to: CTA and outside agency personnel, as necessary

Approved by: William R Mosny
Chief Operating Officer

Supersedes: Safety on Rapid Transit Tracks, 8130 (04-27-03)

Introduction

When entering upon or working adjacent to the right-of-way, ***with or without*** flagging protection, all personnel must follow established safety procedures as specified in General Safety Bulletin #3026, *CTA Employees on the Rail System Right-of-Way* (September, 2007), and current Rail System Rule Book rules. The following guidelines will help you protect yourself and others whenever it is necessary for you to enter the rail system right-of-way.

***NOTE*: All CTA non-operating employees and employees of outside agencies who are assigned to work on or adjacent to CTA's rail system right-of-way must have successfully completed the Rail System Safety Tour and must carry a valid Rail Safety Tour Identification Card.**


CHICAGO TRANSIT AUTHORITY
RAIL SAFETY TOUR IDENTIFICATION CARD
No. 5458 This Certification will
expire on 05/21/2007
Charlie Keevil
Name
99999
Badge/I.D. No.
Affiliation SAMPLE CARD
The personwhose name and photograph appear above satisfactorily completed CTA's Rail Safety Tour on 05/21/2006
Director, Rail Operations

CONDITIONS

1. This card must remain in the possession of the person certified on the front of this card anytime work is being preformed on CTA property.

2. This card is to be presented by the holder upon request of CTA officials.

Outside contractor/agency employee Rail Safety Tour Identification Card
(valid for one year from date of issue)


EMPLOYEE RAIL SAFETY TOUR ID CARD
No. 1328
Charlie Keevil 99999
Name Badge/ID No.
SAMPLE CARD
Title/Position/Area Affiliation/Dept
The person whose name appears above satisfactorily completed CTA's Rail Safety Tour on: 05/21/2004
Expires on: 05/21/2007
Director, Rail Operations

CONDITIONS

1. This card must remain in the possession of the person certified on the front of this card anytime work is being preformed on CTA property.

2. This card is to be presented by the holder upon request of CTA officials.

CTA employee Rail Safety Tour Identification Card
(valid for three years from date of issue)

Communication

- Before entering or working adjacent to the right-of-way:

  - A group shall have a pre-entry safety discussion covering evacuation procedures and safety precautions.
  - One person of the group must be designated as the primary contact with the controller for calling on and off the right-of-way.

- When this is completed, you must notify the controller via radio of your desire to enter the right-of-way. You must call onto and enter the right-of-way (and call off and leave the right-of-way) *from a station* or *between two stations* (if entering the right-of-way at a non-station location).

  - Employees equipped with radios must notify the controller on the proper route channel. Employees with radios not equipped with a route channel must notify the controller via channel 2.

  - If you do not have a radio, you must identify yourself and display your employee ID card to the operator of the next train through the station and request the use of the operator's radio to notify the controller.

  - If no radio is available, call the controller on a telephone.

  Provide the following information to the controller:

  - Who you are and the number of people in your group. If you are a CTA employee, you must also provide your radio call number and your classification.

  - The area where you will be working/on the right-of-way, including the direction of the track upon which you will be working. To ensure that the controller knows exactly where you will be and unless the work area is within the limits of a station, the work area must only be *between two adjacent stations* and must be stated as between those two adjacent stations.

Example:	K570:	K570 to Control.
	Control:	K570, your message.
	K570:	K570, at 87th. Request permission to enter the right-of-way, northbound between 87th and 79th.

    If your location changes, you must *re-call* the controller to call off the prior track area and to call on to the new area. Provide the name of the station through which you are moving and the next *adjacent* station toward which you will now be working/on the right-of-way.

Example:	K570:	K570 to Control.
	Control:	K570, your message.
	K570:	K570, I'm now off the tracks between 87th and 79th. Am now at 79th. Request permission to enter the right-of-way, northbound between 79th and 69th.

  - How long you will be working/on the right-of-way at that location.

Upon the completion of your assignment, notify the controller (from the station at the end of the last work area) that work is complete and to call off the right-of-way.

Personal Protective Equipment

Whenever working on or adjacent to the rail system right-of-way,

- All personnel must wear:
  - Approved CTA high-visibility fluorescent green safety vests,
  - Proper footwear,
  - Protective headwear, if required.
- All personnel must carry a flashlight.
- All groups, even if the group consists of just one person, must possess a working portable flashing yellow light when working in times or places of reduced visibility.

General Precautions

- Be alert; be conscious of hazards presented by the third rail and trains.
- Consider the 600 volt third rail to be energized at all times.
- Never hesitate to signal an operator to slow down or stop if safety is involved; but do not delay service unnecessarily.
- Exercise caution while on the tracks:
  - Stop and look in both directions before crossing a track. Remain in the clear if a train is approaching. Expect trains to run in either direction, on any track, at any time.
  - Avoid walking on or crossing tracks unless necessary. Use the footwalk whenever possible.
  - Step ***over*** rails, never on them.
  - Watch for moving switchpoints. Never stand or place any part of your body on or in movable portions of switches, switchpoints or linkage.
  - Do not allow any part of your body, article of clothing, tools or equipment to contact the third rail or any part of a train.
  - Walk against the normal flow of train traffic whenever possible, so you can observe approaching trains.

Actions When Trains Approach

1. Stop work.
2. Warn others who may not be aware of the approaching train.
3. Face the train and signal the operator to proceed, slow down or stop. Give signals well in advance. If in a group, designate one employee to give all signals.

4. Make certain all equipment is in the clear.

5. Go to a position where you are clear of approaching trains. Make certain you can be seen by the operator of any approaching train.

   - Do not step to an adjacent track unless you are sure it is clear and will remain clear until the train passes.

   - Do not stand between trains on curves or in areas of restricted clearance. If caught/ trapped between trains, lie down on the footwalk, *making sure you don't contact the third rail.*

6. When you are certain that you and all equipment and personnel are in the clear, stand and *face the train*, then signal the operator to proceed. In areas of restricted clearance, do not allow two trains to pass on each side of you at the same time. Flag both trains to a stop. Then give a proceed signal to one train at a time. When two trains are traveling in opposite directions, the loopbound train should be given priority whenever possible.

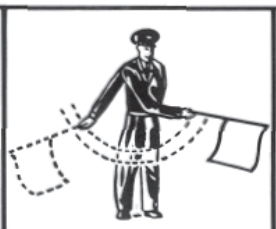
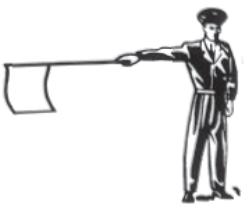
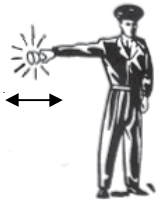
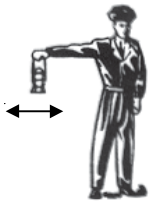
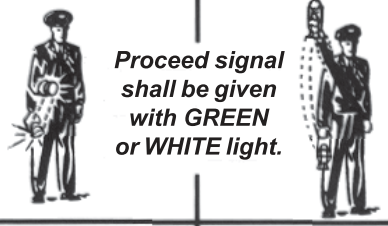
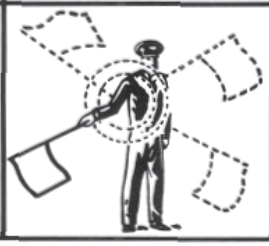
7. Remain stationary and watch the train until the entire train has passed.

8. Notify the controller and your immediate supervisor if the operator fails to respond to signals.

Hand, Flag, Flashlight and Lantern Signals

If your duties require you to give signals, you must ensure that you have the proper equipment, in good working order, ready for immediate use. Flags or lights of the prescribed colors must be used whenever normal operation cannot be maintained in a track area.

- Flags or hand signals must be used during daylight.
- Lights must be used during darkness, periods of low visibility, or in subways.
  - During periods of darkness and in the subway, motion is necessary to ensure recognition. When signalling with a light to reduce speed, slowly move the light back and forth horizontally at shoulder height to ensure that the operator sees and recognizes the signal.
- ***The proceed signal shall NEVER be given with a red flag or any red object.***

<table>
<tr><td>  </td><td>  </td><td>STOP or REMAIN STANDING- Swung horizontally at right angle to track</td><td>  </td><td>  </td></tr>
<tr><td>  </td><td>  </td><td>REDUCE SPEED- Held horizontally at arm's length above track being governed</td><td>  </td><td>  </td></tr>
<tr><td>  </td><td>NOTE: Proceed signal shall NEVER be given with a red flag OR ANY RED OBJECT.</td><td>PROCEED-Raised and lowered vertically above track being governed</td><td colspan="2"> 
Proceed signal shall be given with GREEN or WHITE light.</td></tr>
<tr><td>  </td><td>  </td><td>BACK-Swung vertically in a circle at half-arm's length at right angle to track</td><td>  </td><td>  </td></tr>
</table>

Note: **The relative speed with which a signal is given indicates the relative speed at which compliance with the signal is desired. Any object or hand waved violently by anyone on or near a track is a signal to stop immediately.**

Operator Approaching People On or Near Tracks

- Never operate past anyone on a footwalk or at track level without first receiving a proceed signal and making sure that everyone and all equipment are in the clear. Stand in the motorcab, open the motorcab window and proceed at restricted speed until the entire train is clear of everyone on or near the tracks.
- Warn persons on the tracks by short horn blasts.
- Acknowledge all signals with two short horn blasts.
- Obey all signals, lights and signs.
- Notify the controller to report failure of persons at track level or on footwalks to signal correctly or to stop work and face the train.

SAFETY IS PART OF THE JOB
Follow all CTA-established rules relating to safe operation, as well as those rules relating to use of tools, materials, equipment and personal safety in performance of these procedures.

Title:	**Slow Zones**
Issued to:	All Rail Operations, Engineering and Facilities Maintenance personnel; Capital Construction and outside agency personnel as necessary
Approved by:	 Executive Vice-President, Transit Operations
Supersedes:	Slow zones, 7041 (1-1-86)

A Slow Zone

- is a section of track marked with warning signs and lamps through which trains operate at reduced speed.
- provides protection for people, trains, equipment and tracks.
- is set up when a group (three or more people) is scheduled to work on, across, or near a section of track for one-half hour or more.
- is set up when conditions require, whether or not workmen are present. Examples are: track partially stripped, with spikes out, or needing realignment; guard rail out; or work being done under an elevated structure.

Responsibility for the Slow Zone

The department in charge of the scheduled work has jurisdiction over the slow zone. The same department remains responsible in the event the slow zone must be left unmanned (See *Note*, page 4).

The department with jurisdiction provides all marking devices and accessories.

- Sign/lamp units
- Signpost mounting devices
- Batteries for lamps

Before 1200 hours of the preceding day, the department must initiate an order for a flagman by notifying Operations Systems Support, CTA ext. 6817, which then immediately informs the appropriate terminal clerk.

The terminal clerk assigns flagmen for the next day's assignments if sufficient manpower is available and issues equipment (See SOP 7037: *Flagging on the Right-of-Way*).

SAFETY IS PART OF THE JOB
Follow all CTA-established rules relating to safe operation, as well as those rules relating to use of tools, materials, equipment and personal safety in performance of these procedures.

Set-Up of the Slow Zone

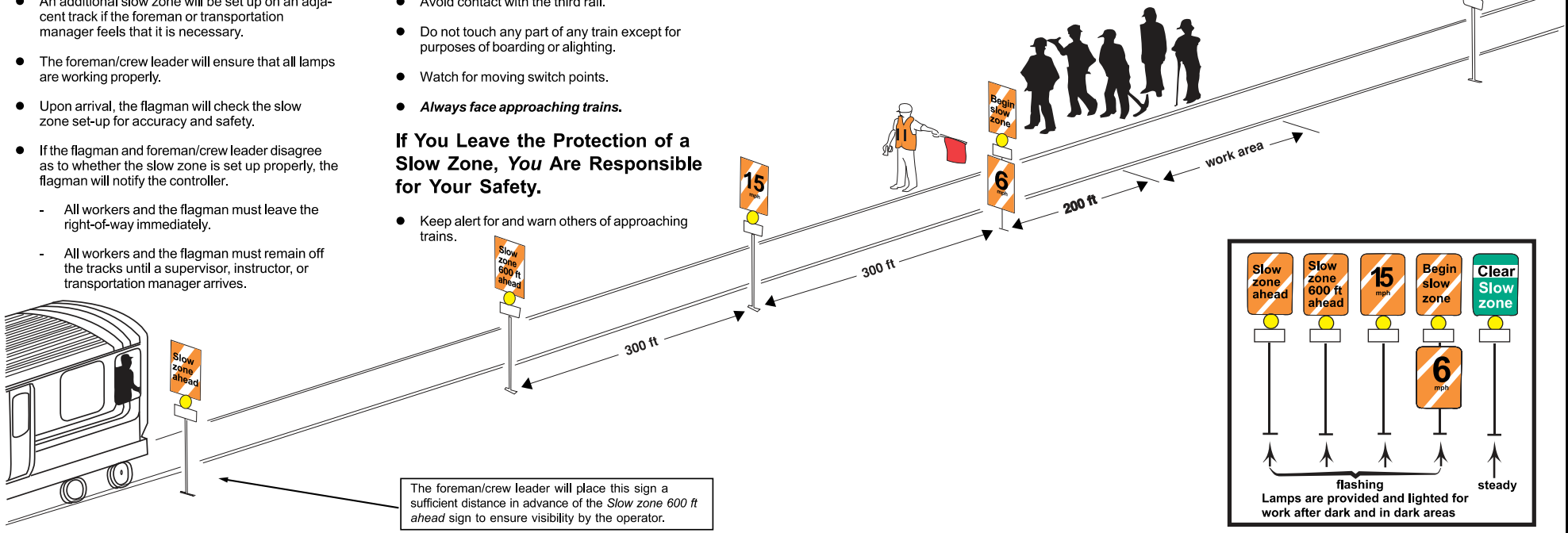
- The foreman/crew leader is responsible for setting up the slow zone as shown in the diagram and for calling the controller when preparing to set up the slow zone.
- If necessary, the foreman/crew leader will extend the distances shown to ensure visibility by train operators.
- The foreman/crew leader will send a worker against traffic a sufficient distance to serve as flagman while the slow zone is being set up.
- The foreman/crew leader and transportation manager will cooperate to keep the length of the work area to a safe minimum.
- The foreman/crew leader will relocate sign posts, flagman and the portable track trip each time the work area progresses 25 feet.
- An additional slow zone will be set up on an adjacent track if the foreman or transportation manager feels that it is necessary.
- The foreman/crew leader will ensure that all lamps are working properly.
- Upon arrival, the flagman will check the slow zone set-up for accuracy and safety.
- If the flagman and foreman/crew leader disagree as to whether the slow zone is set up properly, the flagman will notify the controller.
  - All workers and the flagman must leave the right-of-way immediately.
  - All workers and the flagman must remain off the tracks until a supervisor, instructor, or transportation manager arrives.
  - The supervisor, instructor or transportation manager will evaluate the situation and make any necessary corrections.
- If the *person in charge* at the slow zone deems the track to be unsafe, no trains may enter or pass through the slow zone until the hazard has been corrected.

Safety Requirements for *All* Non-Operating Personnel

- Wear CTA safety vest and hard hat. (Flagmen are not required to wear a hard hat.)
- Notify the controller whenever you are the first person on the track.
- Look both ways before stepping onto any track.
- Always step ***over*** rails - never on them.
- Avoid contact with the third rail.
- Do not touch any part of any train except for purposes of boarding or alighting.
- Watch for moving switch points.
- ***Always face approaching trains.***

If You Leave the Protection of a Slow Zone, *You* Are Responsible for Your Safety.

- Keep alert for and warn others of approaching trains.



- When working alone, stop work well in advance of the train's arrival and remain in full view of approaching trains.
- Slow or stop trains as safety requires.
- Signal the operator to proceed only *after* the track is cleared.

Emergency Evacuation

- The foreman/crew leader must prepare an emergency evacuation plan identifying a clear area for each person. Practice an orderly track evacuation periodically so each person is fully aware of his/her part in the plan. Several short blasts of the flagman's warning horn is a signal to execute the emergency evacuation plan.
- The foreman/crew leader must similarly prepare a plan and train the work crew for emergencies that would require medical or other assistance.
- In the absence of the foreman, a work crew member shall be assigned responsibility for compliance with procedures.
- When work is being performed by a contractor, the contractor is responsible for ensuring that his foreman complies with all procedures.
- Emergencies and violations must be reported by the foreman or CTA construction inspector as soon as possible to the department involved and to the controller.

Standard Operation

1. Once the slow zone has been set up properly, the foreman/crew leader instructs the workers and flagman to begin work.
2. When a train reaches the *Slow zone 600 ft ahead* sign, the flagman sounds the air horn to warn the work crew of the approaching train. Using the red flag or lamp held horizontally over the affected track, the flagman signals the train to reduce speed.
3. As quickly as possible, workers complete tasks sufficiently to assure safe passage of the train.
4. Workers remove tools and materials that could interfere with train operation, move to positions of safety, and ***face the approaching train***.
5. The operator stops the train at any point where signalled to do so. If the operator has not received a proceed signal from the flagman, the train must be stopped *no less than* 1 car length in advance of the *Begin slow zone* sign.
6. The foreman/crew leader signals the flagman when the work area is clear.
7. The flagman then removes the track trip staff, shows it to the operator, and signals the operator to proceed.
8. The operator proceeds at the designated speed until the motorcab passes the *Clear Slow zone* sign. Once the cab has passed the sign, the train may resume normal speed.
9. The flagman replaces the track trip staff as soon as the train clears his/her position.
10. Workers resume work after the train has cleared and it is safe to do so.



Removal of the Slow Zone

1. The foreman/crew leader makes certain that all tools and materials have been removed or secured properly.
2. With the flagman's protection, workers leave the site in single file. As necessary, the foreman/crew leader designates a second flagman to provide protection from both directions.
3. The flagman removes the portable track trip when directed to do so by the foreman/crew leader.
4. With flagman protection, signposts and mounting devices are removed beginning with the *Clear Slow zone* sign and moving forward, in order, removing the *Slow zone ahead* sign last.
5. The flagman notifies the controller when the area is clear.



Note: If a slow zone is to remain after workers leave, the flagman must notify the controller, leave in place the signposts and stands and place an appropriate speed board on the "Begin slow zone" sign.

cta	**Transit Operations** **Standard Operating Procedure**	**Publication Number:** **7038 (06-21-09)**	**Page 1 of 2**

Title: **Train Operation Through Slow Zones**

Issued to: Rapid Transit Operator, Rail Supervisor

Approved by: William R Mo
Chief Operating Offivcer

Supersedes: Train Operation Through Slow Zones, 7038 (05-06-01)

A slow zone

- is a section of track marked with warning signs and lamps through which trains operate at reduced speed.
- is used to protect people working or to limit speed because of some condition on or near the track.

To approach or pass through a slow zone, operate as follows:

1. Begin reducing speed to 15 mph.

Sound horn to alert flagman (succession of short sounds).

2. Begin 15 mph speed limit.

Stand in the motor cab.

Be prepared to stop one car length before reaching the "Begin slow zone" sign.

3. Stop if signaled to do so by the flagman.

Open the window to listen for instructions.

When the flagman shows that the track trip has been removed and gives a "proceed" signal:

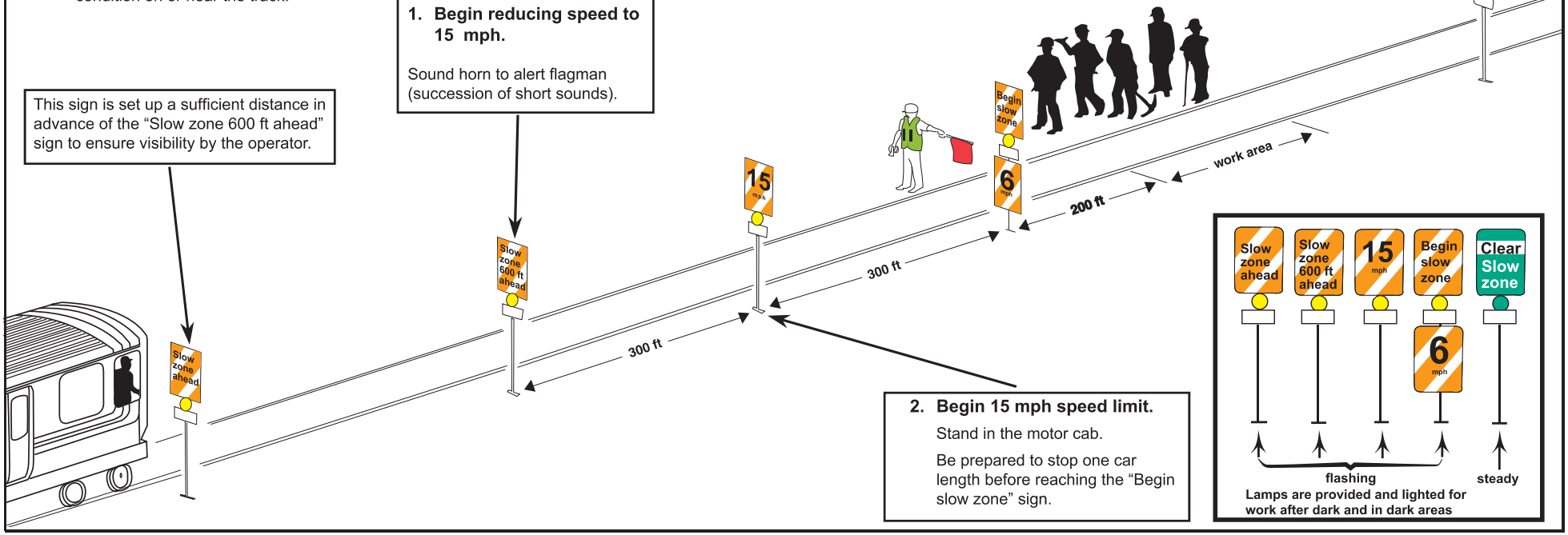
- Acknowledge by train horn (two short sounds).
- Observe the track ahead for obstructions and to ensure that all personnel are clear.
- Proceed at or below the permitted speed until the entire train is clear of the slow zone.

In the absence of a signal to proceed from the flagman:

- Stop and open the window.
- Use the train horn to alert the flagman for a signal (four short sounds).

4. Resume permitted speed once the head car of the train has reached this sign.

This sign is set up a sufficient distance in advance of the "Slow zone 600 ft ahead" sign to ensure visibility by the operator.



	Transit Operations Standard Operating Procedure	Publication Number: 7049 (01-16-05)	Page 1 of 2

Title: **When to Remove 600 Volt Power**

Issued to: All Rail Operations personnel, Rail Controller, Power Controller

Approved by:



Executive Vice-President, Transit Operations

Supersedes: When to Remove 600 Volt Power, 7049 (11-17-02)

Introduction

Request removal of 600 volt power for protection of life or property.

However, removal of power may prevent moving people and equipment to safety. Customers may be inconvenienced, and a delay involving many trains may create an even worse situation than the existing problem. If the situation is not life-threatening and if time and safety allow, the rail controller will notify operators of trains in that power section and instruct them to remain berthed at a station (if already in a station), or to proceed to the next station (if between stations) and remain standing at that station. If the situation *is* life-threatening, the power controller will remove power immediately, regardless of train positions/locations.

To Request Power Off

In a Life-Threatening Emergency:

- Transmit a 10-99 message to the controller via radio, or if necessary by CTA or public telephone at 312-664-7200 x22222, 312-432-8039 or CTA extension 22222.

- Inform the controller:

  - Who you are
  - Where you are
  - The *exact* location and direction of the emergency
  - The nature of the emergency
  - What assistance is needed

- Maintain communication until the controller advises that power has been removed and is being held off.

In a Non-Life-Threatening Situation:

- Inform the controller:

  - Who you are
  - Where you are
  - The reason for the request
  - The *exact* location and direction where you want power removed
  - The anticipated duration of the power removal
  - What assistance is needed, if any

- Maintain communication until the controller advises that the power has been removed and is being held off.

> ***Note:*** **Whenever power is removed, the person requesting the "power off" must remain in the area (unless relieved by the proper authority) to request "power on" when it is safe to do so.**

Only **one** person on the scene may have the hold on power. If the person requesting power off is relieved by a proper authority, both must communicate with the power controller to relinquish power to the newly named individual. The individual taking over the hold on power must accept that responsibility *while on the radio or telephone with the power controller*.

Any hold on power is relinquished to K202 upon his/her arrival at the incident scene and this relinquishment to K202 must be immediately communicated to the power controller.

Possible Alternative Procedures

In some instances, an alternative procedure can be completed in less time than it takes to have power removed. Examples of circumstances under which alternative procedures may be feasible, but not required, are listed below. *These alternatives should be quickly considered and employed if they seem appropriate.* ***If not, request removal of power immediately.***

Example	Possible Alternatives
Person in contact with third rail or power cable.	Remove person from electrical source. Use dry insulating material such as a belt, clothing, rope or piece of wood to break contact.
Defective equipment in consist causes fire on car, or causes short circuit that will not clear.	If near a gap (of at least 40 feet) or street crossing, move car to gap. Otherwise, request removal of power *before* isolating electrical fault. Isolate fault by hooking or tying up third rail shoes and by cutting shoe fuses/shunts.
Ties, structure timber on fire.	Extinguish fire. See procedure(s) on rail system fires and evacuation of trains. Flag approaching trains so they stop short of the danger area.
Broken third rail incline.	Cover broken part with third rail cover box(es).

SAFETY IS PART OF THE JOB
Follow all CTA established rules relating to safe operation, as well as those rules relating to use of tools, materials, equipment, and personal safety in performance of these procedures.

Title: **Workers Ahead Warning System**

Issued to: Rail Operations Personnel and outside agency employees, as necessary

Approved by: William R Mosny
Chief Operating Officer

Supersedes: Workers Ahead Warning System, 8111 (04-28-02)

Introduction

The Workers Ahead (*WA*) warning system is designed to enhance the safety of persons working at track level in areas of limited visibility. The Authority has installed WA warning systems at several locations, but these installations do not relieve or reduce the responsibility of employees to protect themselves and to comply with pertinent safety rules and standard operating procedures. Whenever personnel are present on the right-of-way within a Workers Ahead warning zone, the WA Warning System must be activated. It must be used *in addition to* any slow zones which overlap or are located entirely within the Workers Ahead warning zone.

When the system is activated by an employee at track level, operators of approaching trains will encounter a flashing yellow wayside warning light beneath a sign labeled “BEGIN WA ZONE.” In cab signal territory *only*, when the system is activated, the cab signal indication of maximum allowable speed will be reduced below the normal allowable speed. Generally, in areas where cab signal allowable speed is normally set at (green) 55 mph, allowable speed will be reduced to (yellow) 35 mph or less. However, at some locations on the Orange Line, the allowable speed will be 15 mph.

Note: The speed-reducing feature is NOT in effect when allowable speed has already been reduced due to right-of-way conditions or a train ahead.

When the system is turned off, WA warning lights will be dark, normal speed limits will be in effect and operators may proceed at permitted speed. Rule R6.2 does not apply to these warning lights.

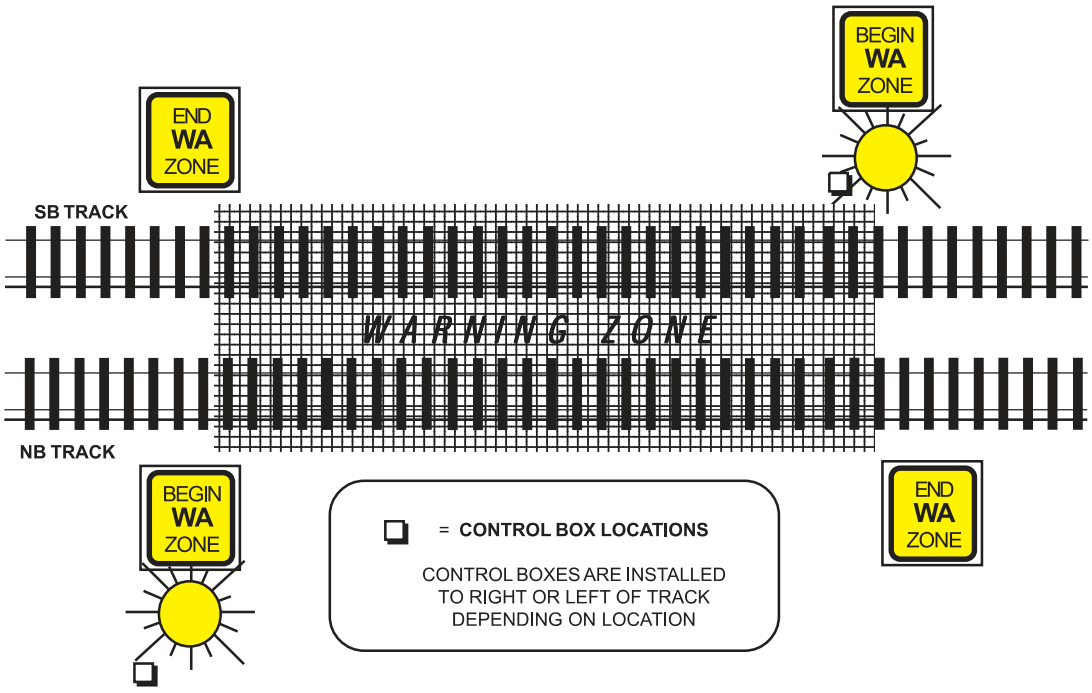
Operators approaching a flashing yellow WA warning light must:

- Reduce speed and sound horn (a succession of short sounds)
- Operate on sight, with extreme caution, expecting to encounter workers ahead through the limits of the WA warning zone.

Operators shall not operate past persons at track level until they receive a proper proceed signal and see that all persons and equipment are in the clear.

The end of the warning zone is identified by a yellow sign with wording “END WA ZONE” in black lettering.

Workers Ahead warning system controls can activate the warning system on one or more tracks to reduce the speed of train traffic **operating in normal direction only.**



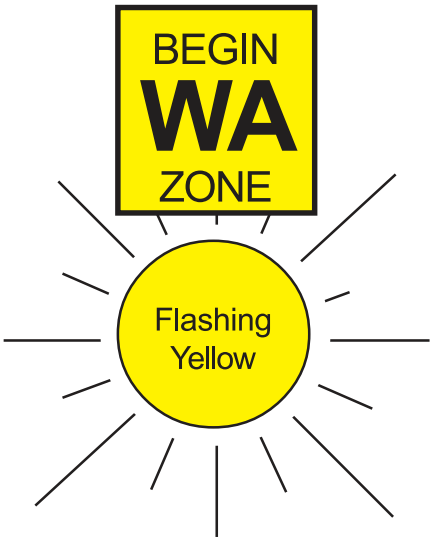
Activating the System

- Before entering the Workers Ahead warning zone at track level, check the Workers Ahead warning light to see if the system is turned on. If the system is already turned on, **leave it turned on**; it indicates that other workers are already in the WA zone. **Notify other workers present that you are also working in the WA zone.** If the system is turned off, unlock the control box and flip the toggle switch to the opposite position. Check to make sure that the red indicator light illuminates to indicate that the WA system is activated. Then close and lock the control box, if it is so equipped.

- Always verify that the WA warning lights are operating properly before beginning any work in the area. If it is not practical to visually check the warning light at the opposite end of the warning zone, flag down the first train that enters the warning zone. **Verify with the operator that the Workers Ahead warning light at the entrance to the warning zone is working properly.**

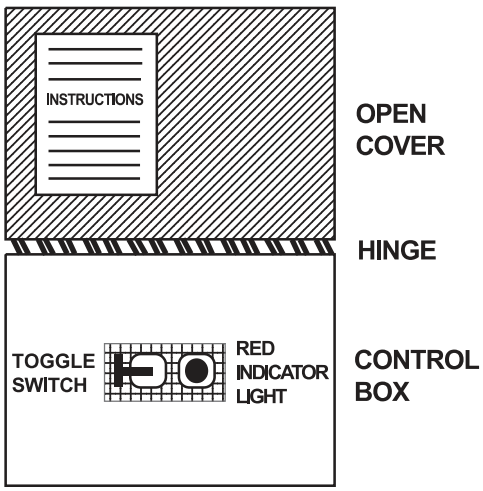
Note: If any warning light fails to illuminate and flash when the system is turned on, notify the rail controller of the defective warning light and await instructions. If necessary, flag a train to a stop and request that the operator report the defect to the controller.

Warning Light and Sign



- yellow plate with black lettering
- "BEGIN WA ZONE" marker and warning light located at the entrance to the warning zone
- the flashing yellow warning light will illuminate when the system is activated
- the light will be dark (off) when the system is turned off

Control Boxes



- painted blaze orange; located at both ends of the warning zone
- the toggle switch turns the system on or off; it controls all the WA warning lights at that location
- the red indicator light illuminates when the system is activated and is dark when the system is turned off
- the control box covers open with a switch lock key

End of warning zone



- yellow plate with black lettering
- "END WA ZONE" marker is located at the exit from the warning zone

Turning Off the System

- If other workers are present when you are leaving the WA zone, leave the system turned on. Multiple crews must coordinate responsibility for turning the system off. If you are sure that no other workers are present, turn the system off. Unlock and open the control box where you are leaving the WA zone and flip the toggle switch to the opposite position. The red indicator light inside the box and the yellow warning lights on the right-of-way will turn off. **Close and lock the control box with the switch lock provided.**

- Leave the WA zone; do not re-enter the WA zone without first re-activating the warning system.

Outside Agencies

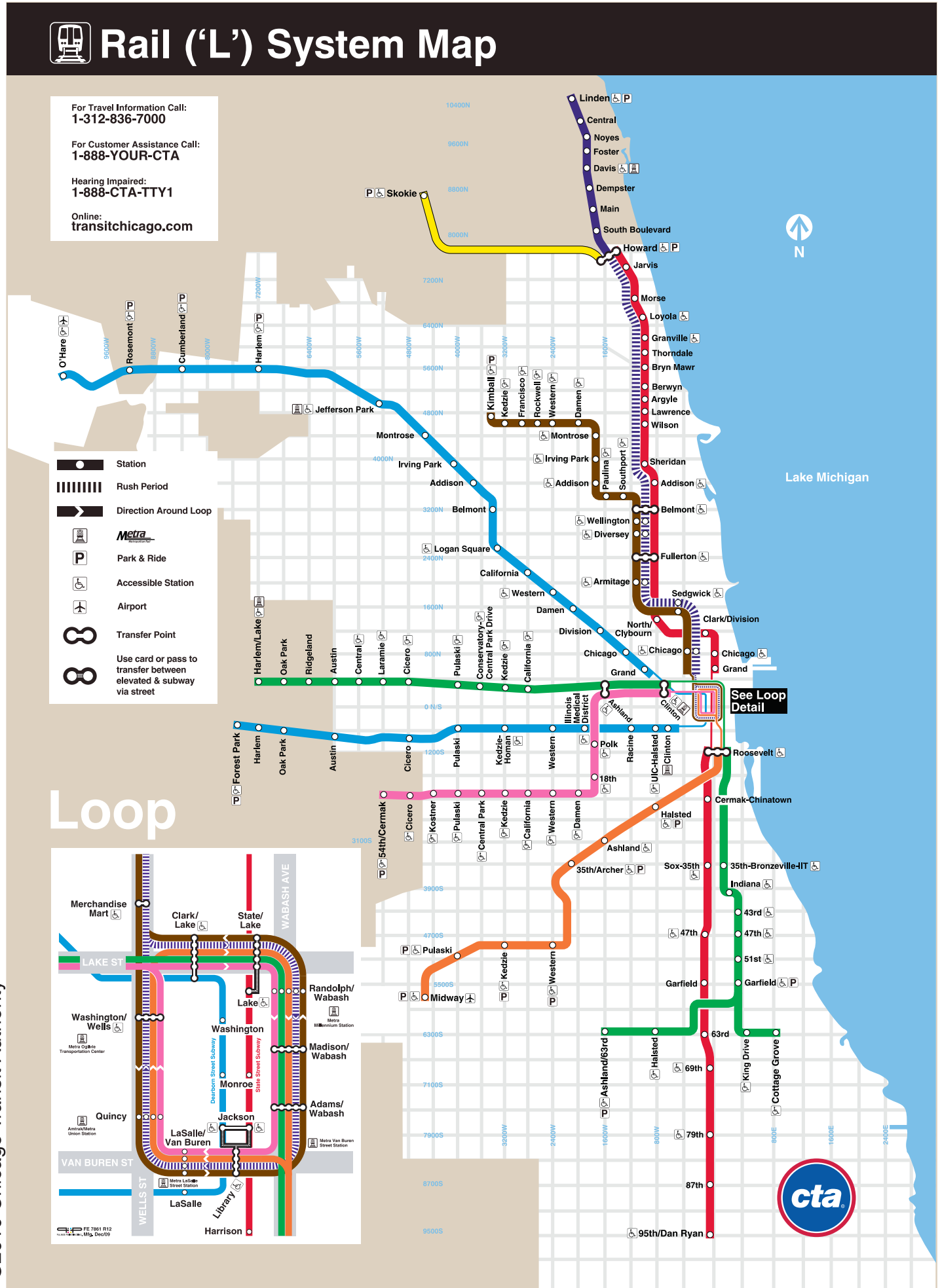
- Representatives of outside agencies must be accompanied by at least one CTA flagman or other authorized CTA employee.

- WA system controls shall be operated *only* by CTA employees.

SAFETY IS PART OF THE JOB

Follow all CTA-established safety rules relating to the use of tools, materials, equipment and personal safety in the performance of these procedures.

Rail ('L') System Map



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Unusual Occurrence Report

1. TIME OF OCCURENCE:		2. DAY:	3. DATE:
4. NATURE OF OCCURRENCE:			5. DELAY:
6. EXACT LOCATION OF OCCURENCE:			
7. RUN NO.:	8. CAR OR BUS NO.:	9. DIRECTION:	10. ROUTE:

COMPLETE DETAILS OF OCCURRENCE

(Include injuries, if any; property or vehicle damage, if any; action taken, if any; supervisor notified)

The series of events are indicated above to show the reasons that K810V returned control of the tracks to CTA about 3 minutes late-at 0503.

1. REPORT PREPARED BY:	2. TITLE:

Signature :_____ **Date:** _____**Time:**_____

Signature :_____ **Date:** _____**Time:**_____

Alcohol & Drug Rules

Prepared By:

The Chicago Transit Authority in conformance with DOT/FTA Regulations for Alcohol Misuse and Drug Abuse.

DOT/FTA ALCOHOL AND DRUG REGULATIONS: AN OVERVIEW

This document provides a general overview of the Department of Transportation (DOT) and Federal Transit Administration (FTA) drug use and alcohol misuse prevention rules for the commercial transportation industries and mass transit in particular . Because the information that follows is a summary of the regulations, copies of the CTA's Drug and Alcohol Policies and Testing Programs are available at your work location, Human Resources (3rd Floor Headquarters), and Employee Relations (10th Floor Headquarters).

INTRODUCTION

Under the Drug-Free Workplace Act of 1988, the U.S. Congress required recipients of federal funds to take certain steps to provide for drug-free workplaces for their employees. Additionally, under the Omnibus Transportation Employee Testing Act of 1991, the U.S. Congress specifically mandated the FTA to issue regulations on drug and alcohol testing for mass transit workers in "safety-sensitive" functions. In response, the FTA has issued two sets of regulations prohibiting drug use and alcohol misuse by all transit employees and requiring transit agencies to test for prohibited drugs and alcohol misuse (49 CFR Part 655). In addition, the DOT has issued Rule 49 CFR Part 40 which establishes procedures for urine drug testing and breath alcohol testing.

WHO IS AFFECTED BY THESE REGULATIONS?

You are subject to testing under DOT/FTA regulation if you are:

(1) A full-time, part-time, seasonal or temporary employee of the CTA performing a "safety-sensitive" function.

(2) Transferring to a position that performs a "safety-sensitive" function.

(3) An employee of a direct contractor engaged in the performance of a "safety-sensitive" function for the Authority.

In general, the FTA regulations state that an employee is performing a "safety-sensitive" function whenever he/she:

(1) Operates a revenue service vehicle (including when not in service).

(2) Operates a nonrevenue service vehicle that requires a driver to hold a commercial driver's license (CDL).

(3) Controls dispatch or movement of revenue service vehicles.

(4) Maintains (including repair, overhaul, and rebuilding) a revenue service vehicle or equipment used in revenue service.

(5) Provides security and carries a firearm.

The above five categories include supervisors who perform these functions. Supervisors of employees in these categories who **do not themselves** perform these functions are excluded.

WHAT ALCOHOL USE IS PROHIBITED?

Because alcohol is a legal substance, the regulations define specific prohibited alcohol-related conduct. Performance of safety-sensitive functions is prohibited:

(1) While having an alcohol concentration of **0.04 or greater** as indicated by an alcohol breath test.

(2) While using alcohol.

(3) Within four (4) hours after using alcohol.

In addition, refusing to submit to an alcohol test and using alcohol within **eight (8) hours after an accident** unless tested (for employees required to be tested) are prohibited.

WHAT ALCOHOL TESTS ARE REQUIRED?

The following alcohol tests are required:

(1) Pre-employment - conducted based on a physician's objective medical judgement or a return to work from EAP.

(2) Post-accident - conducted after certain accidents on employees whose performance could have contributed to the accident.

(3) Reasonable suspicion - conducted when a trained supervisor observes behavior or appearance that is characteristic of alcohol misuse.

(4) Random - conducted on a random, unannounced basis just before, during or just after performance of safety-sensitive functions.

(5) Return-to-duty and Follow-up - conducted when an employee who has violated the prohibited alcohol conduct standards returns to performing safety-sensitive duties. Follow-up tests are unannounced. At least six (6) follow-up tests must be conducted in the first twelve (12) months after an employee returns to duty. Follow-up testing may be extended for up to sixty (60) months following return to duty.

HOW WILL RANDOM ALCOHOL TESTING WORK?

Random alcohol testing must be conducted just before, during and after an employee's performance of safety-sensitive duties. The employee is randomly selected for testing from a "pool" or "pools" of employees subject to testing. The testing dates and times are unannounced and are with unpredictable frequency throughout the year.

Each year, the number of random alcohol tests conducted by the CTA must equal at least ten percent (10%) of the total number of safety-sensitive employees. The regulations provide for adjustments to the annual random testing rate based on the violation (alcohol tests 0.01 or greater and refusals to test) for the entire transit industry. If the alcohol rule violation rate in a given year is one percent (1%) or greater, the annual alcohol testing rate increases to fifty percent (50%). If the alcohol rule violation rate is less than 0.5% for two consecutive years, the random testing rate may be lowered to ten percent (10%). If the violation rate is 0.5% to 1.0%, the random rate remains at ten percent (10%).

HOW WILL ALCOHOL TESTING BE DONE?

The regulations require breath testing using evidential breath testing devices (EBT) approved by the National Highway Traffic Safety Administration (NHTSA). Two (2) breath tests are required to determine if a person has a prohibited alcohol concentration. A screening test is conducted first. Any result less than 0.02 breath alcohol concentration (BAC) is considered a "negative" test. If the result is 0.02 or

greater, a second or confirmation test must be conducted. The employee and the individual conducting the breath test (called a breath alcohol technician (BAT)) complete the alcohol testing form to ensure that the results are properly recorded.

The confirmation tests, if required, must be conducted using an EBT that prints out the results, date and time, a sequential test number and the name and serial number of the EBT to ensure the reliability of the results. The confirmation test result determines any actions taken. Testing procedures that ensure accuracy, reliability and confidentiality of test results are outlined in DOT Rule 49 CFR Part 40. These procedures including training and proficiency requirements for BATs, quality assurance plans for the breath testing devices (including calibration), requirements for a suitable test location, and protection of employee test records.

WHO DOES THE TESTING?

The CTA is responsible for implementing and conducting the testing programs. The regulations permit the CTA to use our own employees, contract services, or by joining together in a consortium that provides services to several member transit agencies. Law enforcement officers will not conduct the tests as part of roadside or other inspections. Any individual who conducts the testing must be trained to operate the EBT and be proficient in the breath testing procedures.

WHAT ARE THE CONSEQUENCES OF ALCOHOL MISUSE?

Employees who engage in prohibited alcohol conduct, i.e., rule violators (confirmed test result of 0.04 BAC or greater), must be immediately removed from safety-sensitive functions. Employees who have engaged in prohibited alcohol conduct cannot return to safety-sensitive duties until they have:

(1) been evaluated by a substance abuse professional (SAP);

(2) complied with any and all treatment recommendations to assist them with an alcohol problem; and

(3) passed a return-to-duty test (which may include both alcohol and drug testing if required by the SAP).

To further ensure transportation safety, employees who have a confirmed test result of 0.02 to 0.039 BAC, when tested just before, during or just after performing safety-sensitive functions, must be removed from performing such duties for eight (8) hours and/or until another breath test is administered and the result is less than 0.02 BAC.

If an employee's behavior or appearance suggests alcohol misuse, a reasonable suspicion alcohol test must be conducted. If a breath test cannot be administered, the employee must be removed from performing safety-sensitive duties for at least eight (8) hours.

HOW WILL EMPLOYEES KNOW ABOUT THESE NEW REGULATIONS?

Employers must provide detailed information about alcohol misuse, the employer's policy, the testing requirements, and how and where employees must attend at least one (1) hour of training on alcohol misuse symptoms and indicators used in making determinations for reasonable suspicion testing.

ARE EMPLOYEES ENTITLED TO REHABILITATION?

Employees who violate the alcohol abuse regulations will be referred to a SAP for evaluation. Under the DOT/FTA regulations, the CTA is not mandated to provide rehabilitation, pay for treatment, or to reinstate the employee in his/her safety-sensitive position. If an employee is eligible to return to safety-sensitive duties, the regulations mandate that the employee:

(1) has been evaluated by a SAP ;

(2) has fully complied with any recommended treatment;

(3) has taken a return-to-duty alcohol test (with a result of less than 0.02); and

(4) is subject to unannounced follow-up alcohol tests.

HOW WILL THE DOT AND FTA KNOW IF THESE REGULATIONS ARE BEING FOLLOWED?

The CTA is required to keep detailed records of their alcohol misuse prevention programs. The FTA will conduct inspections or audits of transit agency programs. Additionally, selected agencies will have to submit annual MIS reports to the FTA. These reports will be used to help monitor compliance with and enforcement of the regulations, as well as to provide data on the extent of alcohol misuse problems and the need for any further program or regulatory changes.

ARE EMPLOYEE ALCOHOL TESTING RECORDS CONFIDENTIAL?

Yes. Employee alcohol testing records are confidential. Test results and other confidential information may only be released to the CTA and the SAP. Any other release of this information is only with the employee's consent. If the employee initiates a grievance, hearing, lawsuit or other action as a result of a violation of these regulations, the CTA may release relevant information to the decision maker. Such information also may be released when requested by the DOT or any DOT agency with regulatory authority over the CTA or any of its employees.

ARE THESE REGULATIONS WORTH THE COSTS?

There are significant safety benefits from preventing alcohol misuse. These regulations will help prevent tragic, costly transportation accidents as well as help to improve worker productivity, decrease health care costs, and lessen worker absences.

Although the regulations will be costly to implement because there are so many employees subject to testing, the DOT has carefully balanced safety, individual rights, and costs. The potential safety benefits to employees, employers and the public outweigh the costs.

WHAT ABOUT DRUG TESTING?

The FTA has issued a rule requiring drug testing of safety-sensitive transit employees also beginning in January 1995. The drug testing regulations cover the same categories of safety-sensitive employees as the alcohol testing regulations. The types of tests required are the same as for alcohol: Pre-employment; reasonable suspicion; post-accident; random; return-to-duty and follow-up.

HOW IS DRUG TESTING DONE?

The DOT drug and alcohol testing procedures rule (49 CFR Part 40) sets forth the procedures for drug testing in all transportation industries, including mass transit. Drug testing is conducted by analyzing an employee's urine specimen. The analysis is performed only at laboratories certified and monitored by the Department of Health and Human Services (DHHS). There are over 90 DHHS certified drug testing laboratories in the United States. The list of DHHS approved laboratories is published monthly in the Federal Register.

The employee provides a urine specimen in a location that affords privacy and the "collector" seals and labels the specimen, completes a chain-of-custody document, and prepares the specimen and accompanying paperwork for shipment to a drug testing laboratory. The specimen collection procedures and chain-of-custody ensure that the specimen's security, proper identification, and integrity are not compromised.

The Omnibus Act requires use of split-specimen collection procedures. Each urine specimen is subdivided into two bottles labeled as "primary" and a "split" specimen. Both bottles are sent to a laboratory. Only the primary specimen is opened and used for urinalysis. The split specimen bottle remains sealed and is stored in the laboratory. If the analysis of the primary specimen confirms the presence of illegal, controlled substances, the employee has seventy-two (72) hours to request the split specimen to be sent to another DHHS certified laboratory for analysis. This split-specimen procedure essentially provides the employee with an opportunity for a "second opinion".

WHAT DRUGS ARE TESTED FOR?

All urine specimens are analyzed for the following drugs:

(1) Marijuana (THC Metabolite)
(2) Cocaine
(3) Amphetamines
(4) Opiates (including heroin)
(5) Phencyclidine (PCP)

HOW ARE URINE SPECIMENS TESTED FOR DRUGS?

The testing is a two-stage process. First, a screening test is performed. If it is positive for one or more of the drugs, then a confirmation test is performed for each identified drug using gas chromatography/mass spectrometry (GC/MS) analysis. GC/MS confirmation ensures that over-the-counter medications or preparations are not reported as positive results. GC/MS is a state-of-the-art testing process and is considered by the DOT to be the most sophisticated and accurate form of analysis available.

WHO REVIEWS AND INTERPRETS THE LABORATORY RESULTS?

All drug test results are reviewed and interpreted by a physician (Medical Review Officer (MRO))before they are reported to the CTA. If the laboratory reports a positive result to the MRO, the MRO contacts the employee (in person or by telephone) and conducts an interview to determine if there is an alternative medical explanation for the drug(s) found in the employee's urine specimen. For all the drugs except PCP, there are some limited, legitimate medical uses for the drugs that may explain the positive test result. If the employee provides appropriate documentation and the MRO determines that it is legitimate medical use of the prohibited drug, the test is reported as negative to the CTA.

WHAT DRUG USE IS PROHIBITED?

The drug regulations prohibit any unauthorized use of the controlled substances. Illicit use of drugs by safety-sensitive employees is **prohibited on or off duty.** In addition, CTA regulations prohibit use of legally prescribed controlled substances (such as barbiturates, amphetamines, morphine, etc.), by employees. Furthermore, CTA regulations require employees to report any medical use of controlled substances.

WHAT ARE THE CONSEQUENCES OF A POSITIVE DRUG TEST?

As with an alcohol misuse violation, a safety-sensitive employee must be removed from safety-sensitive duty if he/she has a positive drug test result. The removal cannot take place, however, until the MRO has interviewed the employee and determined that the positive drug resulted from the unauthorized use of a controlled substance. An employee with a confirmed positive test result by the MRO **cannot** be returned to safety-sensitive duties until he/she has been evaluated by a SAP, complied with recommended rehabilitation, and has a negative result on a return-to-duty drug test. Follow-up testing to monitor the employee's continued abstinence from drug use is also required.

HOW DOES RANDOM DRUG TESTING WORK?

The CTA is responsible for conducting random, unannounced drug tests. The total number conducted each year must equal a percentage as determined by the **DOT (25%-2007), (50%-2006)** of the safety-sensitive employees. Some employees may be tested more than once each year; some may not be tested at all depending on the random selection. Unlike random testing for alcohol, random testing for drugs **does not** have to be conducted in immediate time proximity to the performance of safety-sensitive functions. Once notified of selection for testing, however, an employee must proceed to the designated collection site to accomplish the urine specimen collection.

The DOT has issued a proposal to permit adjustment to the random drug testing rate. The proposal is similar to what is required for random alcohol testing. The random drug testing rate would be determined annually based upon the random positive rate for each industry. If, for example, the transit industry's positive rate for two consecutive years is less than one percent (1%), the random testing rate would decrease to twenty-five percent (25%). If the transit industry's positive rate is one percent (1%) greater in any given year, the random rate would be fifty percent (50%). As with random alcohol testing, the industry's positive rates would be calculated from data submitted annually by transit agencies. Rate adjustments would occur in January of the year following submission of the MIS reports, where applicable.

ARE EMPLOYEE EDUCATION AND TRAINING REQUIRED?

The CTA must provide information on drug use and treatment sources to safety-sensitive employees. A minimum one (1) hour training on the dangers of controlled substance abuse is required. In addition, supervisors of safety-sensitive employees must attend a minimum one (1) hour training on the signs and symptoms of drug abuse. This training is necessary to assist supervisors in making appropriate determinations for reasonable suspicion testing.

ARE EMPLOYEE DRUG TESTING RECORDS CONFIDENTIAL?

Yes. Employee drug testing results and records are maintained under strict confidentiality by the CTA, the drug testing laboratory, and the medical review officer. They cannot be released to others without the written consent of the employee. Exceptions to these confidentiality provisions are limited to DOT agencies when license or certification actions are required or to a decision maker in arbitration, litigation or administrative proceedings arising from a positive drug test. Statistical records and reports are maintained by the CTA and the drug testing laboratory. This information is aggregated data and is used to monitor compliance with the regulations and to assess the effectiveness of the drug testing programs.

WHERE CAN I GET MORE INFORMATION?

Specific information and copies of the alcohol and drug rules can be obtained from the DOT/FTA/CTA offices listed below. The address is:

400 7th Street, S.W.
Washington, D.C. 20590
(for each office except USCG)

Alcohol and Drug Testing Procedures
Office of the Secretary
Drug Enforcement and Program Complaint
Room 9404
(617) 494-2395

Mass Transit
Federal Transit Administration (FTA)
Office of Safety and Security
Room 6432
(202) 366-2896

CTA Employee Relations Department
567 West Lake Street, 10th Floor
(312) 681-4114

CTA Employee Assistance Program
Managed by Comp Psych
1-800-557-1005

Advance Occupational Medicine Specialists *(Medical Review Officer)*
614 West Monroe Street
(312) 258-0700
www.AOMSclinic.com