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Volume 2 of 2

RPM Phase One -
Broadway Substation Upgrade

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Submitted By:

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Submitted To:

cta

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BROADWAY SUBSTATION UPGRADES

BROADWAY SUBSTATION
5847 N. BROADWAY STREET
CHICAGO, IL 60660

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SECTION 23 00 00
HEATING, VENTILATING AND AIR CONDITIONING

PART 1 GENERAL

1.01 SCOPE OF WORK

A. The Contractor shall furnish all labor, material, equipment, and services necessary to furnish Heating, Ventilating and Air Conditioning Systems at the location(s) shown on the Drawings and/or as specified herein.

1.02 RELATED DOCUMENTS

A. Drawings and general provisions of contract, including General and Special Conditions and Division 01 Specification Sections, apply to this Section.

1.03 RELATED WORK

A. Section 23 07 00 Mechanical Insulation

B. Section 23 00 10 Ventilation

1.04 QUALITY ASSURANCE

A. Reference Standards:

1. The American Society of Heating, Refrigeration Air Conditioning Engineers Guides (ASHRAE).

2. Sheet Metal and Air Conditioning Contractors' National Association, Inc. SMACNA "HVAC Duct Construction Standards, Metal and Flexible", and SMACNA, "Manual for the Balancing and Adjusting of Air Distribution Systems".

3. The Underwriters' Laboratories (UL) listings or approvals shall govern quality and performance of the electrical products specified herein.

4. American National Standards Institute (ANSI) B31.5 Refrigeration Piping.

5. Chicago Electrical Code, latest edition.

6. American Society for Testing and Materials:
   a. ASTM A36, Structural Steel.
   b. ASTM A527, Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-forming Quality.
   c. ASTM B209 Aluminum-Alloy Sheet and Plate.
   d. ASTM B32, Soldered Joints

7. Federal Specifications:

   a. FF-B-588C, Bolts, Toggle, and Expansion Sleeve (Screw).
   b. FF-S-107C(2), Screws, Tapping and Drive.
   c. FF-S-325, Shield, Expansion; Nail, Expansion and Nail Drive Screw (Devices, Anchoring, Masonry).

8. National Fire Protection Association:

   a. NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating

Systems.
b. NFPA 90B, Standard for the Installation of Warm Air Heating and Air Conditioning Systems.
c. NFPA 255, Method of Test of Surface Burning Characteristics of Building Materials.

9. American Society of Mechanical Engineers (ASME).

10. National Electric Manufacturer's Association (NEMA).

11. AMCA Compliance, Test and rate air handling units in accordance with AMCA standards.

12. ARI Compliance, Test and rate air handling units in accordance with ARI 430 "Standard for Central-Station Air handling Units", display certification symbol on units of certified models.

13. ASHRAE Compliance, Construct and install refrigerant coils in accordance with ASHRAE 15 "Safety Code for Mechanical Refrigeration".

14. UL and NEMA Compliance, Provide electrical components required as part of air handling units, which have been listed and labeled by UL and comply with NEMA Standards.

15. NEC Compliance, Comply with National Electrical Code (NFPA 70) as applicable to installation and electrical connections of ancillary electrical components of air handling units.

16. City of Chicago Building Code.

17. American Welding Society (AWS).

1.05 SUBMITTALS

A. The Contractor shall furnish shop drawings, product data and samples in accordance with the requirements below:

1. Product Data:

a. Ductwork Layout & Details.
b. Ductwork Accessories.
c. Grilles, Registers, Diffusers, Gravity & Counter Balanced Dampers and Louvers.
d. Fans and other air handling equipment.
e. Forced Air Wall Heaters
f. Air Filters
g. Automatic Damper electric operators.
h. Piping and Duct Insulations.
i. Controls.
j. Thermostats.

2. Shop drawings

a. Equipment, Ductwork, Piping layout and details.
b. Electrical wiring plans and control diagram
c. Schedule of equipment

3. The Contractor shall furnish operating instructions and maintenance recommendations/requirements in accordance with the below:

   a. Operation Instructions.
   b. Manufacturer's Catalog Sheets.
   c. System Line Diagrams.
   d. Panel Layout Drawings.

4. Certificates:

   a. Brazing Certification: Certify brazing procedures, brazers and operators in accordance with ASME standards (ANSI B31.5).
   b. Welding Certification: Certify welding procedures, welders, and operators are in accordance with ASME and AWS Standards.
   c. Americo.

1.06 SEQUENCING/SCHEDULING

A. The Contractor shall schedule and perform tasks required for furnishing and installing the Heating, Ventilating and Air Conditioning Systems in conformance with the requirements of the accepted project schedule.

1.07 DELIVERY, STORAGE AND HANDLING

A. In accordance with the General Conditions and provisions of contract requirements.

B. Deliver all equipment with factory-installed (wooden) skids and suitable lifting lugs; or deliver equipment, components, and accessories in factory-fabricated protective containers.

C. Protect all delivered equipment and materials from foreign matter, weather (rain, wind, dirt/debris), and other damage at all times.

D. Inspect all equipment and materials for damage prior to installation. Remove from the construction site all damaged or corroded materials and equipment.

PART 2 PRODUCTS

2.01 SHEET METAL STANDARDS

A. Iron and Steel Sheets (Galvanized): Lock forming quality (LFQ) with 1-1/4 oz. (36 g) galvanizing total on both sides per sq. ft. (0.09 sq.m) of sheet.

2.02 DUCTWORK MATERIALS

A. General: The thickness of the sheet metal and size and spacing of the stiffeners used shall be in accordance with the requirements of the latest edition of the SMACNA, "HVAC Duct Construction Standards, Metal and Flexible". "Low Velocity Duct Construction Standards."

   1. Low Pressure (Up to 2" S.P. (0.5 kPa) Ductwork: Construct in accordance with the requirements of the SMACNA "HVAC Duct Construction Standards, Metal and Flexible".

B. Material: Galvanized sheet steel unless otherwise specified.

C. Duct Sealant: All joints and seams in supply ductwork shall be sealed with fire resistive duct sealer. Sealer shall be buttered on seams and joints during fabrication and erection.

D. Acceptable Manufacturers:

1. Minnesota Mining and Manufacturing Co., Duct Sealer EC800.

2. Benjamin Foster, 30-02 Fire Resistive Duct Sealer.

3. United Sheet Metal, United Duct Sealer.

E. Connections and Details: Connections to diffusers, grille and register faces shall be absolutely airtight. All slip joints shall be made in the direction of flow, and unless otherwise indicated on the drawings, all radius elbows shall have a centerline radius equal to 1-1/2 times the width of the duct.

F. Rectangular Ductwork: Groove and Pittsburgh lock seams and slip joints shall be used for all rectangular ducts unless otherwise specified.

2.03 FLEXIBLE CONNECTIONS

A. General: Flexible fabric connections to prevent the transmission of vibration through the ducts shall be UL classified and shall be installed on both the supply and return sides of all fans and ventilating units and at building expansion joints, and approximately where shown on the drawings. Fabric used for flexible connections shall be of proper weight and strength for the service required, and shall be properly fitted to render it airtight. Fabric shall be of sufficient width to provide a minimum space of 4" (10 cm) between connected items, and with sufficient slack to prevent tearing due to fan movement.

B. Fabric - General Usage: 30-oz. (0.8 kg) fiber glass fabric, fire retardant and airtight, coated with neoprene on both sides, and with firmly attached extra wide galvanized metal edges.

C. Acceptable Manufacturers:

1. Ventfabric Inc., Ventglas.

2. Elgen, Neoprene Fabriduct.

2.04 GRILLES, REGISTERS, DIFFUSERS, GRAVITY DAMPERS, COUNTER BALANCED DAMPERS AND LOUVERS

A. General: Grilles, registers and diffusers shall be of the sizes indicated, with white finish coat unless otherwise specified, and shall be supplied with gaskets to prevent air leakage around side of units. Screw holes in frames shall be countersunk for flat head screws.

B. Exhaust Registers: Single deflection type with 3/4" blade spacing; horizontal 35^{o} degree face bars and opposed blade dampers.

C. Supply Registers: Fully adjustable discharge pattern, 4-way pattern with opposed blade dampers.

D. Acceptable Manufacturers (See Appendix A):

1. Titus

2. Metal Aire

3. Carnes

4. Krueger

E. Dampers shall be heavy duty Ruskin (See Appendix A), Air Warming or Penn backdraft dampers or approved equal with counterbalancing as required. Frame shall be of .081" thick extruded aluminum and damper blades shall be .070" minimum thickness extruded aluminum.

F. Louvers shall be sized per drawings to fit in wall opening and be 4" and 6" deep as shown on the drawings, stainless steel with insect screen. Provide a stormproof design. Acceptable manufacturers include Penn, Airstream, Ruskin (See Appendix A), Vent Products or approved equal.

2.05 FANS, GENERAL

A. Factory-built Units: Fans in Factory-Built Units shall be unit manufacturer's standard type, unless otherwise specifically indicated. Construction shall be in conformance with AMCA standards for the volume and pressure rating for the fan.

B. Identification: All fans shall bear metal identification nameplates indicating area served, CFM (cubic meters/second), H.P. (watts), RPM, SP (pascals), and size. Fan capacities shall be based on operating at the static pressures indicated at 70 degree F (21 degree C) and 29.92" (101 kPa) of mercury, barometric pressure. Fans shall bear the AMCA label.

2.06 SUPPLY AND EXHAUST FANS

A. Furnish and install where noted on the drawings propeller or in line blower type supply fans and exhausters. Fan housings shall be of heavy gauge aluminum construction and shall be weatherproof, incorporating an integral weather shield. Fans shall be mounted on the floor, roof curbs or in wall as shown on the drawings.

1. Fan wheels shall be propeller or centrifugal design that have been statically and dynamically balanced. Tip speed, rpm, and motor horsepower shall not exceed listing in manufacturer's catalog for unit specified.

2. Fans shall have integral factory-formed base fabricated to the dimensions shown on the drawings. Housings shall be provided with wiring channel and are to be of the direct discharge design. Motor and fan assembly shall be on vibration isolating mounts. Fans shall have sizes as scheduled. Provide a speed controller located in the motor housing as scheduled on drawings. Sone level shall be limited to 18.0.

3. Fans shall be provided with integral unit mounted disconnect switches.

B. Belts: The fans, where specified, shall be connected to the driving motor by means of a V-belt drive, with a minimum of 2 strands, unless otherwise designated. 2-strand V-belt drives shall be designed for 100% overload capacity, multiple strand V-belt drives shall be designed for 50% overload capacity, and the motors for such drives shall be equipped with adjustable bases or slide rails. Multiple belts shall be matched. When replacement of one or more belts of a set is necessary, entire set shall be replaced with new matched belts. Multiple belts shall be so designed as to minimize whip, turn over and throw off.

C. Sheaves: It shall be the responsibility of the Contractor to see that all design static pressures are met. Provide adjustable sheaves for design static pressure. Provide adjustable sheaves for one or two-strand belt drives. Sheaves shall be selected to operate at the mid-point of the fan curve so as to allow adjustment in both directions. For multiple-strand drives, provide fixed sheaves. Replace fan sheaves as necessary to obtain desired results. All fan sheaves and motor sheaves shall be dynamically and statically balanced before assembly.

D. Wheels and Bearings: Wheels shall be heavily and rigidly constructed and accurately balanced both statically and dynamically, and be free from objectionable vibration or noises. Bearings shall be medium-duty, self-aligning, ball or roller bearing, sealed, pillow block type, and shall be complete with lubrication fittings, extended for easy access where necessary.

E. Acceptable Manufacturers

1. Loren Cook.

2. Greenheck.

3. Penn.

4. Or approved equal.

F. Shafts: Fabricate of steel, with first critical speed of wheel and shaft of not less than 1.25 times the maximum speed specified. All shafting be turned, ground and polished to close tolerances.

G. Fan Curves: Furnish performance curve data sheet with shop drawings of fans submitted for review. All fan performance ratings and data shall be AMCA certified ratings in accordance with Standard AMCA test code method and procedure.

2.07 IN-LINE EXHAUST FANS

A. General: Shall be complete with 120 volt, 60 hertz, direct drive single phase motor. Fans shall have true centrifugal wheel and backdraft damper. Housing shall be acoustically insulated galvanized steel. Sone level shall be limited to 18.0. Motor shall be matched to blower wheel assemblies. Fan motors shall be suitably grounded and mounted on vibration isolators.

B. Furnish and install where shown on drawings. Fans shall have sizes as scheduled.

C. Acceptable Manufacturers:

1. Loren Cook

2. Penn

3. Greenheck

4. Or approved equal

2.08 HIGH VOLUME LOW SPEED CEILING FANS

A. Fans shall comply with UL standard 507 and CSA standard 22.2 No 113., NFPA 72 for installation with sprinkler systems. Controllers shall comply with NEC and UL standards as required.

B. Motor, drive and controller shall be warranteed for 10 years from the date of acceptance of the installation.

C. Airfoils shall be aluminum with stainless steel bolts, nuts and lock washer connections to the hub.

D. Motor shall be permanent magnet type rated for continuous operation at maximum speed.

E. Fan drive shall be either through a variable speed motor or a gearbox capable of operating the fan through a range of 20% to 100% of full speed.

F. Units shall include a wired, wall mounted, adjustable thermostat for the control of the fan operation.

G. Fans shall be as manufactured by Big Ass Fan, Rite-Hite Fans, or approved equal.

2.09 VIBRATION ISOLATION MOUNTS

A. General: Support in-line cabinet fans with double deflection neoprene mount type vibration isolators. Isolators shall have plated screws and washers and shall be of size required for the application, with 0.35" deflection.

B. Acceptable Manufacturers:

1. Mason Type NDA Black.

2. Vibration Mountings and Controls, Inc.

3. Or approved equal.

2.10 FAN-FORCED WALL HEATERS

A. Enclosures shall be constructed from minimum 16 gauge steel, commercial quality, suitable to withstand heavy duty use.

B. Enclosures shall be chemically treated to resist corrosion then finished in baked enamel and satin finished aluminum frame. Color shall be submitted for approval.

C. Back panel shall be painted, completely finished and suitable for installation on concrete block construction with applied finish scheduled on the Drawings.

D. Motor and blower fans are direct drive connection and mounted as a single assembly on rigid heavy gauge frame for long, vibration free life.

E. Steel finned metal sheath heating element shall be center anchored, and ensure noiseless expansion and contraction.

F. Units shall have overheat protection over the entire length of the element through a capillary type cut out. Overheat protection shall restore operation automatically when cause of overheat is removed from the element.

1. As scheduled or specified in the contract documents, furnish units with integral, adjustable thermostats.

G. Acceptable Manufacturers: Trane, Chromolox, or approved equal.

1. Q-Mark

2. Markel

3. Trane

4. Or approved equal

2.11 REPLACEABLE THROWAWAY AND ROLL FILTERS

A. Description: Factory-fabricated, viscous-coated, flat-panel type, replaceable air filters with holding frames in sizes and having performance characteristics as required.

B. Media: Throwaway media of interlaced glass fibers, sprayed with nonflammable adhesive.

C. Frame: Cardboard frame with perforated metal retainer for flat filters.

D. Duct Holding Frames: 16-gage (0.9mm) galvanized steel capable of holding media and media frame in place, with gaskets to prevent unfiltered air bypass.

E. Roll filters: Casings shall be galvanized steel with an upper dispensing unit to accommodate the media roll, a lower rewind unit for the used media, a drive motor and gear assembly to advance the media and a control unit to actuate the drive system. The drive shall advance the media based on and infrared sensor, calibrated to actuate the drive when the level of dirt accumulation reaches a pre-defined level.

F. Acceptable Manufacturers:

1. American Air Filter Co.

2. Farr Co.

3. Continental Air Filters.

4. Cambridge Filter Corp.

2.12 UNIT HEATERS

A. Unit heater casings: Die-formed heavy gauge steel with baked enamel finish and shall include stamped louver air inlet, adjustable outlet louvers and access door with schematic for the system affixed to the door interior.

B. Heating elements shall be all steel finned type with copper brazed fins.

C. Motors shall be TEFC.

D. Fan speeds shall not exceed 1600 rpm.

E. Units shall be fully factory wired, including thermal overload protection and fusing, transformers, if required, and either unit mounted or remote thermostats with adjustable setpoints.

2.13 BASIC PIPES AND PIPE FITTINGS

A. General: Provide pipe, tube, and fittings in accordance with the following listing:

1. Tube Size 3/4" and Smaller: Copper Tube: Type ACR, soft annealed temper fittings; cast copper-alloy fittings for flared copper tubes; flared joints.

2. Soldered Joints: Solder joints using silver-lead solder, ASTM B 32, Grade 96 TS.

B. Gas piping shall be schedule 40 black steel with threaded fittings and 150lb PSIG ball valves for isolation.

2.14 CONTROL DEVICES

Controls covered in specification sections 23 73 33, 23 83 13 and 23 83 33.

2.15 AUTOMATIC DAMPERS

A. General: Automatic motorized dampers shall have frames of minimum 13 gauge (2.3mm) galvanized steel not less than 2" (50 mm) in width and aerodynamically formed blades of 16 gauge (1.5 mm) galvanized steel. Dampers shall be adequately braced to form a rigid assembly. No dampers shall have blades more than 4" (10 cm) wide. Length of blades shall be not more than 48" (122 cm). Blades shall be secured to ½" (13 mm) diameter zinc plated axles by zinc plated bolts and nuts. All blade bearings shall be nylon or bronze. Teflon coated thrust bearings shall be provided at each end of every blade to minimize torque requirements and insure smooth operation. All blade linkage hardware shall be constructed of corrosion resistant, zinc plated steel and brass.

B. Size and Selection: Dampers shall be suitable for operation within a temperature limit range of -40 to 200 degrees F. (-39.8 to 93 degrees C.) The control manufacturer shall submit leakage and flow characteristics plus a size schedule for all controlled dampers.

1. Dampers shall be of the parallel design with replaceable butyl, spring stainless steel or closed cell neoprene edging.

2. Dampers located adjacent to intake louvers shall be furnished in sizes as indicated.

C. Acceptable Manufacturers:

1. Ruskin

2. Vent Products

3. Or approved equal

2.16 ELECTRIC OPERATORS

A. General: Actuators for dampers shall be two-position line voltage (120 Volt AC) with manually adjustable minimum position and with lock, reversing type as required by the application. Where specified or required by the application, actuators shall have a spring mechanism to return the damper to a predetermined position in the event of a power interruption. Actuators shall have position indicators to show the position of the actuator over the full stroke.

B. Damper Operation Locations: Damper motors shall be installed and attached to the frame of the damper, and connected to an extended shaft, as required, in order to meet the specific conditions of the job.

C. Acceptable Manufacturers:

1. Honeywell

2. Ruskin

3. Barber-Coleman

4. Siebe

5. Siemens

6. Or approved equal

2.17 MISCELLANEOUS EQUIPMENT

A. Provide necessary two-position, capacity and electric sequencing relays and miscellaneous items required for the successful operation and sequencing of the systems herein specified. Relays and switches shall be UL listed, and of voltage and current characteristics to meet application.

PART 3 EXECUTION

3.01 INSPECTION

A. Examine areas and conditions under which units shall be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 EQUIPMENT INSTALLATION

A. The following mechanical equipment shall be installed, wired with controls and placed in operating condition.

1. Fans as listed in Fan Schedule.
2. Automatic Dampers.
3. Power Roof Ventilators.
4. Forced-Fan Wall Heaters.
5. Air Filters (roll and flat)
6. Space Heaters
7. Ductwork
8. Grilles, Registers, Diffusers, Gravity and Counter Balanced Dampers and Louvers.

B. Electric wall mounted disconnect switch shall be furnished, installed and wired under Division 34.

C. All necessary starters for exhaust fan motors as shown on electric schematic diagrams shall be furnished, installed and wired under Division 34.

D. Fan and damper interlocks shall be as defined on the drawings. Operation for automatic dampers and fans shall be as indicated on the electrical schematic drawings.

3.03 DUCTWORK INSTALLATION

A. The fabrication of all ductwork and fittings shall be executed in a neat and competent manner by a manufacturer experienced in this class of work. It shall be true to size and free from sharp edges and projections both internally and externally.

B. Ductworks shall be fabricated and installed as per SMACNA "HVAC Duct Construction Standards".

C. Where a metal duct passes through a wall, roof or other building structure, it shall be isolated from the structure by a layer of bituminous felt over which shall be superimposed a 25 mm thick layer of mineral wool flexible slab to which the opening shall be made good. Fire dampers shall be installed as per approved detailed drawings.

D. All ductwork shall be supported in such a manner that no weight is imposed upon the plant to which it is connected.

3.04 INSTALLATION OF FAN FORCED WALL HEATER.

A. Install heaters as indicated, in accordance with equipment manufacturer's written instructions, and with recognized industry practices, to ensure that heating terminal equipment fulfills requirements. Comply with applicable installation requirements of NEC and NECA's "Standard of Installation".

B. Coordinate with electrical work, including wiring/cabling work, as necessary to interface installation of heating terminals with other work.

C. Clean dust and debris from heater as it is installed to ensure cleanliness.

D. Comb out damaged fins where bent or crushed before covering elements with enclosures.

E. Touch-up scratched or marred heater enclosure surfaces to match original finishes.

F. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Std. 486A.

G. Grounding:

1. Provide equipment grounding connections as indicated. Tighten connections to comply with tightening torque values specified in UL Std. 486A to assure permanent and effective grounds.

3.05 INSTALLATION OF AIR FILTERS

A. Install filter frames level and plumb, following manufacturer's written instructions, rough-in drawings, the original design, and referenced standards.

B. Install air filters and holding devices of types indicated and where shown following air filter manufacturer's written instructions and with recognized industry practices to ensure that filters comply with requirements and serve intended purposes.

C. Locate each filter unit accurately in position indicated in relation to other work. Position unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

D. Install filters in position to prevent passage of unfiltered air.

3.06 CONNECTIONS

A. Flexible joints shall be provided on the inlet and outlet connection to each fan, on ducts crossing building expansion joints and elsewhere in the ductwork; if so indicated on the drawings or where necessary to meet the requirements of the noise and vibration control.

B. Coordinate filter installations with fans, dampers, duct and air conditioning unit installations.

C. All ductwork and other connections shall be adequately braced and stiffened where necessary to prevent sagging, drumming and vibration.

3.07 ELECTRICAL WIRING

A. General: Install electrical devices furnished by manufacturer but not specified to be factory-mounted.

B. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division-34 sections. Do not proceed with equipment start-up until wiring installation is acceptable to the Authority.

3.08 INSTALLATION OF TEMPERATURE CONTROL

A. Temperature controls covered in specification sections 23 73 33, 23 83 13 and 23 83 33.

3.09 ADJUSTMENT AND CLEANING

A. General: After construction is completed, including painting, clean unit exposed surfaces, vacuum clean terminal coils and inside of cabinets.

B. Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.

C. After testing, adjusting, and balancing air conditioning and air-distribution systems, clean outside air intake and clean filter housings and install new filter media.

3.10 TESTING, BALANCING AND COMMISSIONING

A. Upon completion of installation of the system and after building circuitry has been energized, test, balance and commission the system to demonstrate operability and compliance with requirements. Field correct malfunctioning units, then retest to demonstrate compliance.

B. Submit tests sheets for record and documentation.

END OF SECTION

SECTION 23 00 10
VENTILATION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. The Contractor shall furnish all labor, material, equipment and services necessary to furnish ventilating systems including exhaust fans and ductwork at the locations shown on the Drawings and/or as specified herein.

1.02 RELATED DOCUMENTS

A. Drawings and Division 01 Specification Sections, apply to this Section.

1.03 RELATED WORK

A. Division 26 Sections, Electrical.
B. Section 23 00 00 Heating, Ventilating and Air conditioning

1.04 QUALITY ASSURANCE

A. Reference Standards:

1. Sheet Metal and Air Conditioning Contractors' National Association, Inc. SMACNA "HVAC Duct Construction Standards, Metal and Flexible".
2. The Underwriters' Laboratories (UL) listings or approvals shall govern quality and performance of the electrical products specified herein.
3. Chicago Electrical Code, latest edition.
4. City of Chicago Building Code
4. American Society for Testing and Materials:

   a. ASTM A527, Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-forming Quality.
   b. ASTM B32, Soldered Joints

5. National Fire Protection Association:

   a. NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
   b. NFPA 255, Method of Test of Surface Burning Characteristics of Building Materials.

6. American Society of Mechanical Engineers (ASME).
7. National Electric Manufacturer's Association (NEMA).
8. AMCA Publications 211 and 311.
9. AMCA Certified Ratings Program for sound and air performance.
10. AMCA Standard 204-05, Balance Quality and Vibration Levels for Fans.
11. ASHRAE American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.

1.05 SUBMITTALS

A. The Contractor shall furnish shop drawings, product data and samples in accordance with the requirements of Division 01 Section, Submittals.

1. Product Data:

a. Ductwork Materials.
b. Ductwork Accessories.
c. Grilles, Registers, Diffusers, Louvers.
d.
e. Controls.

2. Specifications, wiring diagram, ratings and installation instructions for exhaust fans.

3. Shop Drawings:

a. Equipment, Ductwork layout and details.
b. Electrical wiring plans and control diagram
c. Schedule of equipment

4. The Contractor shall furnish operating instructions and maintenance recommendations/requirements in accordance with the requirements of Division 01 Section, Project Closeout, for exhaust fans and controls.

1.06 SEQUENCING/SCHEDULING

A. The Contractor shall schedule and perform tasks required for furnishing and installing the ductwork and exhaust fans in conformance with the requirements of the accepted project schedule.

1.07 WARRANTY

A. All materials, installation, equipment, connections and controls shall be warrantied for a period of one year after date of final acceptance. Make any required repairs or replacements during that time period to the satisfaction of the Authority and at no cost to the Authority.

1.08 DELIVERY, STORAGE AND HANDLING

A. In accordance with the General Conditions and provisions of contract requirements.
B. Deliver all equipment with factory-installed (wooden) skids and suitable lifting lugs; or deliver equipment, components, and accessories in factory-fabricated protective containers.
C. Protect all delivered equipment and materials from foreign matter, weather (rain, wind, dirt/debris), and other damage at all times.
D. Inspect all equipment and materials for damage prior to installation. Remove from the construction site all damaged or corroded materials and equipment.

PART 2 PRODUCTS

2.01 SHEET METAL STANDARDS

A. Iron and Steel Sheets (Galvanized): Lock forming quality (LFQ) with 1-1/4 oz. (36 g) galvanizing total on both sides per sq. ft. (0.09 sq.m) of sheet.

2.02 DUCTWORK MATERIALS

A. General: The thickness of the sheet metal and size and spacing of the stiffeners used shall be in accordance with the requirements of the latest edition of the SMACNA, "HVAC Duct Construction Standards, Metal and Flexible". "Low Velocity Duct Construction Standards."

1. Low Pressure (Up to 2" S.P. (0.5 kPa) Ductwork: Construct in accordance with the requirements of the SMACNA "HVAC Duct Construction Standards, Metal and Flexible".

B. Material: Galvanized sheet steel unless otherwise specified.

C. Duct Sealant: All joints and seams in supply ductwork shall be sealed with fire resistive duct sealer. Sealer shall be buttered on seams and joints during fabrication and erection.

D. Acceptable Manufacturers:

1. Minnesota Mining and Manufacturing Co., Duct Sealer EC800.
2. Benjamin Foster, 30-02 Fire Resistive Duct Sealer.
3. United Sheet Metal, United Duct Sealer.

E. Connections and Details: Connections to diffusers, grille and register faces shall be absolutely airtight. All slip joints shall be made in the direction of flow, and unless otherwise indicated on the drawings, all radius elbows shall have a centerline radius equal to 1-1/2 times the width of the duct.

F. Circular Ductwork: Groove and Pittsburgh lock seams and slip joints shall be used for all ducts unless otherwise specified.

2.04 GRILLES, REGISTERS, DIFFUSERS, AND LOUVERS

A. General: Grilles, registers, diffusers and louvers shall be of the sizes indicated, stainless steel unless otherwise specified, and shall be supplied with gaskets to prevent air leakage around side of units. Screw holes in frames shall be countersunk for flat head screws.

B. Exhaust Registers: Single deflection type with 3/4" blade spacing; horizontal 35^{o} degree face bars and opposed blade dampers.

C. Acceptable Manufacturers:

1. Titus
2. Metal Aire
3. Carnes
4. Krueger

2.05 FANS, GENERAL

A. Factory-built Units: Fans in Factory-Built Units shall be unit manufacturer's standard type, unless otherwise specifically indicated.

B. Identification: All fans shall bear metal identification nameplates indicating area served, CFM (cubic meters/second), H.P. (watts), RPM, SP (pascals), and size. Fan capacities shall be based on operating at the static pressures indicated at 70 degree F (21 degree C) and 29.92" (101 kPa) of mercury, barometric pressure. Fans shall bear the AMCA label.

2.06

PART 3 EXECUTION

3.01 INSPECTION

A. Examine areas and conditions under which fans, grilles, registers, diffusers, louvers and ductwork shall be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 EQUIPMENT INSTALLATION

A. The following mechanical equipment shall be installed, wired with controls and placed in operating condition according to the manufacturer's instructions:

1.
2. Ductwork
3. Grilles, Registers, Diffusers, and Louvers.
4. Supports

3.03 DUCTWORK INSTALLATION

A. The fabrication of all ductwork and fittings shall be executed in a neat and competent manner by a manufacturer experienced in this class of work. It shall be true to size and free from sharp edges and projections both internally and externally.

B. Ductworks shall be fabricated and installed as per SMACNA "HVAC Duct Construction Standards".

C. Where a metal duct passes through a wall, roof or other building structure, it shall be isolated from the structure by a layer of bituminous felt over which shall be superimposed a 25 mm thick layer of mineral wool flexible slab to which the opening shall be made good. Fire dampers shall be installed as per approved detailed drawings.

D. All ductwork shall be supported in such a manner that no weight is imposed upon the plant to which it is connected.

3.03 ELECTRICAL WIRING

A. General: Install electrical devices furnished by manufacturer but not specified to be factory-mounted.

B. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to the Authority.

3.04 ADJUSTMENT AND CLEANING

A. General: After construction is completed, including painting, clean unit exposed surfaces, vacuum clean inside of housings.

B. Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.

3.05 TESTING, BALANCING AND COMMISSIONING

A. Upon completion of installation and after building circuitry has been energized, test, balance and commission the system to demonstrate operability and compliance with requirements as per equipment schedule. Where possible, field correct malfunctioning units, then retest to demonstrate compliance.

B. Submit test sheets for records and documentation.

END OF SECTION

SECTION 23 07 00
MECHANICAL INSULATION

PART 1 GENERAL

1.01 SCOPE OF WORK:

A. The Contractor shall furnish all labor, material, equipment, and services necessary to furnish and install thermal duct insulation and equipment insulation at the location as directed and required by the Authority.

1.02 RELATED DOCUMENTS:

A. General provisions of Contract apply to this Section.

1.03 RELATED WORK:

A. Section 22 07 00, Pipe Insulation.
B. Section 22 40 00 Plumbing
C. Section 23 00 00 Heating, Ventilating and Air Conditioning

1.04 SUBMITTALS

A. The Contractor shall furnish product data, technical data, samples, installation instructions and shop drawings as required below:

1. Product Data: Provide product description, list of materials, and thicknesses for each type and application of insulation, cement, adhesive, sealant, tape, attachment device, jacket, cover and other accessory.

    a. Provide specifications and test data indicating thermal performance standards of insulating products.
    b. Provide data for each insulating product indicating thickness of material and related R value.

2. Provide product data, specifications, technical data and shop drawings for any equipment insulation indicating thickness, R values, size and profile of equipment to be insulated, location of protrusions, access requirements, method of attachment and seam closure method.
3. Samples: Submit two (2) samples of any representative size illustrating each insulation and accessory type. Provide samples of any jackets or covers in actual color and finish to be supplied.
4. Manufacturer's installation instructions: Indicate procedures which ensure acceptable workmanship and installation standards will be achieved.
5. Manufacturer’s certificate of compliance and thermal efficiency.
6. Copy of manufacturer’s warranty.

1.05 QUALITY ASSURANCE

A. Manufacturer of insulation shall have been producing the products successfully for a period of at least five years and be able to provide documentation that the products meet all specified requirements.

B. The material(s) required for the work will be furnished by the Contractor. All material(s) furnished by the Contractor shall be new and shall meet the standards and requirements specified by the applicable institutions and organizations (i.e. ASME, ASTM, NFPA, and EPA), and local building codes.

C. All installation of insulation shall follow the insulation manufacturer’s recommended procedures and meet the standards and requirements specified by the applicable institutions, organizations, Federal, State, and Local building codes.

1.06 REFERENCE STANDARDS

A. American Society for Testing and Materials:

1. ASTM E 84, Surface Burning Characteristics of Building Materials.

B. National Fire Protection Association:

1. NFPA 255, Method of Test of Surface Burning Characteristics of Building Materials.

C. Underwriters' Laboratories:

1. UL 723 Fire and Smoke Hazard Classification.

1.07 SEQUENCING/SCHEDULING

A. A. The Contractor shall schedule and perform tasks required for furnishing and installing the thermal insulation and accessories in conformance with the requirements of the accepted project schedule.

B. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactorily passed the quality control test procedures.

1.08 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver insulation products to the site in unbroken shipping cartons bearing a label indicating the contents and the appropriate ASTM, NFPA and UL flame and smoke hazard ratings as specified herein for the various insulation products.

B. Deliver and store insulation products protected from the weather. Store insulation on the site elevated off wet and otherwise contaminating surfaces.

1.09 ENVIRONMENTAL REQUIREMENTS

A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.

B. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 PRODUCTS

2.01 THERMAL INSULATING MATERIALS, GENERAL:

A. Rigid Thermal Insulation: Use rigid insulation manufactured of molded glass fiber with composite (insulation, jacket or facing, and sealing adhesive) fire and smoke hazard ratings meeting requirements of NFPA 90A Standards, tested per ASTM E 84, NFPA 255 and UL 723, not to exceed a "Flame Spread" rating of 25 and a "Smoke Developed" rating of 50 except as noted herein. Products or their shipping cartons shall bear a label indicating above requirements. Insulation shall have a maximum thermal conductivity of 0.23 BTUH per sq. ft. per degree F. per inch at 70 degrees F. mean temperature. The water vapor transmission rating shall be less than 0.2 perms per inch using a jacket of white kraft bonded to aluminum foil and reinforced with fiberglass yarn.

B. All exterior ductwork and/or equipment shall be insulated with cellular glass type insulation having integral self-sealing jacket.

C. Fitting Insulation (Rigid): Insulate fittings and valve bodies with factory pre-molded one-piece insulation. Insulation inserts of noncombustible glass fiber shall have a K factor of .27 at 75 degrees F. mean temperature.

2.02 DUCT AND EQUIPMENT INSULATION

A. Preformed rigid or soft insulation composed of calcium silicate, cellular glass, flexible elastomeric, mineral or glass-fiber blanket, mineral or glass-fiber board, phenolic, polyisocyanurate, polyolefin or polystyrene as submitted and approved by the Authority.

B. Acceptable Manufacturers of duct insulation (depending on material):

1. The Industrial Insulation Group.
2. Cell-U-Foam Corporation.
3. Pittsburg Corning Corporation.
4. Aeroflex USA, Inc.
5. Armacell LLC.
6. RBX Corporation.
7. CertainTeed Corporation.
8. Johns Manville.
9. Knauf Insulation.
10. Manson Insulation.
11. Owens Corning.
12. Fiberex Insulations, Inc.
13. Rock Wool Manufacturing Company.
14. Roxul Inc.
15. Thermafiber.
16. Kingspan Corporation.
17. Apache Products Company.
18. Dow Chemical Company.
19. Duna USA Inc.
20. Elliott Company.
21. Nomaco Inc.
22. Approved Equal.

2.03 INSULATING CEMENTS

A. Mineral Fiber certified to meet the requirements specified in the current edition of ASTM C 195.

- Thermal Conductivity: Average max. 1.0 $BTU \times in./h \times ft^2 \times {}^oF$ at 500 ^oF mean temperature.
- Minimum compressive strength: 10 p.s.i. at 5 percent deformation.

B. Mineral Fiber, Hydraulic-Setting Insulating and Finishing Cement certified to meet the requirements specified in the current edition of ASTM C 449.

- Apparent Thermal Conductivity: Average max. 1.2 $BTU \times in./h \times ft^2 \times {}^oF$ at 400 ^oF mean temperature.
- Minimum compressive strength: 100 p.s.i. at 5 percent deformation.

2.04 PREFORMED GLASS FIBER

A. Molded and jacketed inorganic glass fibers, bonded with a thermosetting resin, into products preformed via a molding process to yield rigid full-round cylindrical pipe insulation sections, certified to meet the requirements specified in the current edition of ASTM C 547, for Type I insulation.

- Apparent Thermal Conductivity: Average max. 0.26 $BTU \times in./h \times ft^2 \times {}^oF$ at 75 ^oF mean temperature.
- Density: Average max. 10 lb/ft^3

B. Surface Burning Characteristics: All preformed glass fiber insulation shall have composite (insulation, jacket, tape seal, and adhesive used to adhere the jacket to the insulation) Fire and Smoke Hazard ratings as tested in accordance with the current editions of ASTM E 84, NFPA 255 and UL 723, not exceeding

- Flame Spread 25
- Smoke Developed 50

C. Hot-Surface Performance: All preformed glass fiber insulation shall not flame, glow, smolder, crack, delaminate or warp after 96 hours exposure to the heated surface of a heating pipe when tested in accordance with the current edition of ASTM C 411.

D. Jacketing: The preformed glass fiber insulation shall be furnished with either a foil and paper jacket with end joint butt strips or an aluminum jacket. All jacketing shall conform to the requirements specified herein under Article 3.1.5-Jackets.

2.05 JACKETS

A. Foil and Paper Jacket- Laminated glass-fiber-reinforced, flame-retardant Kraft paper and aluminum foil having self-sealing lap conforming to the current edition of ASTM C 1136, Type I, and ASTM C 921, Type I or Type II.

- Water Vapor Permeance: 0.02 perms maximum, when tested in accordance with the current edition of ASTM E 96.
- Puncture Resistance: 50 beach units minimum, when tested in accordance with ASTM D 781-84.

B. Aluminum Jacket - Aluminum jacketing material shall be Alloy 3003, H14 temper roll stock, ready for shop or field fabrication to required sizes, in compliance with the current edition of ASTM B 209.

- Finish and Thickness: Smooth finish, 0.010 inch to 0.016 inch thick.
- Moisture Barrier: Factory applied 1-mil, heat bonded polyethylene and Kraft paper.
- Moisture Barrier: Factory applied 3-mil Dupont Surlyn, or approved equal.

C. Aluminum fitting jackets shall be factory preformed from the same material having the same finish, moisture barrier, and thickness as that specified for jackets.

D. All straight runs of pipe insulation are to be protected with Childers Corrolon or approved equal aluminum jacketing. The jacketing is to be manufactured from .016" type 3003 or 5005 aluminum. All jacketing shall have an integrally bonded polykraft moisture barrier over the entire surface in contact with the insulation. All jacketing shall be installed in accordance with manufacturer’s latest published recommendations.

E. All 90 degree F and 45 degree F insulated elbows having a nominal iron pipe size of ½" to 12", inclusive, shall be protected with Childers Aluminum Ell-Jacs or approved equal manufactured from 1100 Aluminum alloy in .024" thickness. The Ell-Jacs shall be installed in accordance with manufacturer's latest published recommendations.

2.06 STANDARD PVC FITTING COVERS

A. Factory-fabricated fitting cover consisting of one-piece, pre-molded, PVC covers manufactured from 20-mil thick, high-impact, ultraviolet-resistant PVC.

- Shapes: 45- and 90-degree, short- and long-radius elbows, reducers, end caps, soil-pipe hubs, traps, mechanical joints, roof drains, and P-trap, in compliance with the current edition of ASTM C 585.

- Smooth high gloss surface that does not promote bacteria or fungi growth.

2.07 ATTACHMENTS, ADHESIVES AND SEALANT MATERIAL

A. Metal bands shall be 3/4 inch wide x 0.020 inch thick Type 304 stainless steel.

B. Wire tie material shall be one of the following: 14 gage nickel-copper alloy, 16 gage soft-annealed stainless steel, or 16 gage soft-annealed galvanized steel as indicated in the contract document.

C. Adhesives for the flexible elastomeric cellular insulation shall be solvent based, and suitable for the insulation furnished as recommended by the insulation manufacturer.

D. Adhesives for rigid preformed glass fiber insulation shall be non-flammable, solvent based and have a service temperature range of minus 20 ^{o}F to plus 180 ^{o}F.

E. Vapor Barrier Compound shall be a water-based fire-resistive composition exhibiting the following characteristics.

- Water Vapor Permeance: 0.08 perm maximum.
- Temperature Range: Minus 20 ^{o}F to plus 180 ^{o}F.

F. Weatherproof Sealant: Flexible-elastomer-based, vapor barrier sealant designed to seal metal joints.

- Water Vapor Permeance: 0.02 perm maximum.
- Temperature Range: Minus 50 ^{o}F to plus 250 ^{o}F.
  Color: Aluminum.

PART 3 EXECUTION

3.01 INSPECTION

A. Carefully inspect installed work of other Trades in connection with insulating work and verify such work shall be complete, including system or equipment testing, to such point where insulating work may begin.

B. Verify that ductwork and/or equipment has been tested and approved before applying insulation materials.

3.02 PREPARATION

A. Apply insulation on clean, dry surfaces only and without foreign materials. Perform cleaning required for removal of construction debris, spills, etc. prior to installation.

3.04 INSTALLATION

A. Install materials in accordance with manufacturer's instructions.

B. Install insulation continuous through structure penetration of surfaces being insulated. All duct insulation shall be continuous through walls, ceilings, floor openings or sleeves except where firestop or fire-safing materials are required.

C. Insulation installed on ductwork or equipment operating below ambient temperatures shall have a continuous vapor barrier. Adequately seal hanger, support, and anchor penetrations of insulation. All joints, seams and fittings shall be sealed with approved materials.

D. Apply specified insulation adhesive, sealers and coatings at the manufacturer's specified minimum coverage per gallon.

3.05 PIPING INSULATION:

A. Apply insulation materials on ductwork and equipment in accordance with thicknesses recommended by manufacturer for local climatic conditions. Insulate fittings and valve bodies and in-line control devices, except gage and thermometer faces, setting or measuring scales integral with in-line devices and control handles.

B. Rigid Insulation Installation: Install on ductwork or equipment according to manufacturer's instructions, using specified adhesive to seal both longitudinal jacket laps and butt strips. Insulate in-line appurtenances with factory pre-molded one-piece insulated covers as previously specified. Secure fitting cover by stapling first followed by a tape sealing using tape specified by the fitting cover manufacturer.

C. For exterior applications, provide vapor barrier jacket. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining ductwork, and finish with glass mesh reinforced vapor barrier cement applied in two inch thick coats. Install the glass reinforcing mesh in the first coat while tacky and allow to dry before applying the second coat. Cover with aluminum jacket with seams located on bottom side of horizontal piping and facing building wall on vertical pipe. Secure cover with ½ inch wide aluminum draw brands on maximum 2 foot (610 mm) centers, or edges with aluminum sheet metal screws on maximum 4 inch (102 mm) centers. Caulk seams with flexible latex caulking.

D. For buried ducts, provide factory fabricated assembly with inner all-purpose service jacket with self-sealing lap, and asphalt impregnated open mesh glass fabric, with one mil (0.025 mm) thick aluminum foil sandwiched between three layers of bituminous compound; outer surface faced with a polyester film.

E. Insulate ductwork and equipment less than 8 feet above finished floors in locations accessible to personnel contact so that temperatures of exposed surfaces do not exceed 180 degrees F (82 degrees C).

G. Carry vapor barriers down and seal to the cold surface at not more than 50 foot (15 meters) intervals on horizontal runs and at not more than 10 foot (3 meters) intervals on vertical runs.

H. Seal hangers on ducts carrying air of less than 70 degrees F (21 degrees C) to a point of 2 inches (51 mm) minimum above the top of the insulation where the insulation is penetrated.

I. Vapor barrier jackets may be all purpose jackets, foil-scrim-kraft jacket, minimum 3 mil plastic sheeting, or spray on plastic coatings.

J. Provide a factory or field applied fiberglass cloth jacket over all vapor barriers, except all-purpose jackets, on all piping exposed to view or specified to be painted.

K. Provide a factory or field applied fiberglass cloth jacket over all thermal insulation exposed to view or specified to be painted, except all-purpose jackets. Size all insulation exposed to view in accordance with section painting.

L. Adhesives and fasteners used to secure jackets and covers on insulation shall be vermin, rodent and mildew resistant and have a smoke and flame spread rating equal to or greater than the insulation on which applied.

M. Apply insulation so that it does not interfere with the operation of control valves or servicing of equipment, valves or controls. Apply insulation so that access doors, covers, panels and access plates on equipment and piping can be removed, opened or operated without damage to the insulation. Insulation shall not cover nameplates, inspection stamps, rating plates, code stamps, and similar information attachments.

N. On high-temperature ducts, provide double layering of insulation. Stagger insulation joints when more than one layer of insulation is applied.

O. All ends of insulation materials shall be firmly butted and secured with appropriate butt strip materials.

P. When installing insulation cover seams, locate in the least visible location. All surface finishes shall be extended in such a manner as to protect all raw edges, ends and surfaces of insulation.

3.06 CLEANUP

A. The Contractor shall ensure a general clean-up is conducted at all work sites at the close of each workday. All waste material or rubbish (e.g. old insulation) must be disposed of in accordance with all applicable City and State regulations in effect for the work area, including disposal of waste in a licensed yard and/or refuse land fill.

B. Contractor shall not dispose of waste material or rubbish into the Authority's refuse containers or anywhere else on or about the Authority's property.

C. Contractor shall keep premises free from accumulation of waste material or rubbish as the work progresses. At completion of work, the Contractor shall remove all rubbish from the worksite and shall remove all tools, scaffolding and surplus materials, leaving the work area "broom clean". In case of dispute, the Authority may remove rubbish and charge such costs to the Contractor. Any damages caused by the Contractor, either directly or indirectly, shall be the sole responsibility of the Contractor.

3.07 DEFECTIVE MATERIALS OR WORKMANSHIP

A. All material and workmanship covered by this specification shall be subject to the inspection and approval of the Authority and shall be in conformance with this specification, all relevant codes and requirements and good practice. All materials used for this work shall be new, in original packaging and undamaged prior to installation.

B. Any defective material shall be immediately removed from the premises by the Contractor and replaced at no cost to the Authority. Any defective workmanship shall be promptly corrected to the satisfaction of the Authority and at no cost to the Authority.

END OF SECTION

SECTION 23 73 33.16
INDOOR, INDIRECT, GAS-FIRED SPACE HEATING UNITS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section includes indirect, gas-fired heating and ventilating units.

1.03 DEFINITIONS

A. DDC: Direct digital control.

1.04 ACTION SUBMITTALS

A. Product Data: For each type and configuration of indoor, indirect, gas-fired heating and ventilating unit.

   1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each type and configuration of indoor, indirect, gas-fired heating and ventilating unit.

   1. Signed, sealed, and prepared by or under the supervision of a qualified professional engineer.
   2. Include plans, elevations, sections, and mounting details.
   3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   4. Detail fabrication and assembly of gas-fired heating and ventilating units, as well as procedures and diagrams.
   5. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.
   6. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
   7. Include diagrams for power, signal, and control wiring.

1.05 INFORMATIONAL SUBMITTALS

A. Startup service reports.
B. Sample Warranty: For manufacturer's special warranty.
C. Seismic Qualification Certificates: For indoor, indirect, gas-fired heating and ventilating units, accessories, and components, from manufacturer.

   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For indirect-fired heating and ventilating units to include in emergency, operation, and maintenance manuals.

1.07 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Belts: Oneset(s) for each unit.

1.08 QUALITY ASSURANCE

A. Comply with NFPA 70.
B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.09 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of indirect, gas-fired heating and ventilating units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than 10 years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Hastings, Engineered Air or as approved equal.

2.02 SYSTEM DESCRIPTION

A. Factory-assembled, prewired, self-contained unit consisting of cabinet, supply fan, controls, and indirect-fired gas burner to be installed inside the building.
B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.03 UNIT CASINGS

A. General Fabrication Requirements for Casings:

1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
2. Casing Joints: Sheet metal screws or pop rivets, factory sealed with water-resistant sealant.

3. Factory Finish for Steel and Galvanized-Steel Casings: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-on enamel finish, consisting of prime coat and thermosetting topcoat.
4. Casing Coating: Powder-baked enamel.
5. Air-Handling-Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.

    a. Seismic Fabrication Requirements: Fabricate mounting base and attachment to air-handling-unit sections, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when air-handling-unit frame is anchored to building structure.

6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Configuration: Vertical unit with top or horizontal discharge for floor-mounted installation.
C. Cabinet: Aluminized- or galvanized-steel panels, formed to ensure rigidity and supported by galvanized-steel channels or structural channel supports with lifting lugs. Duct flanges at inlet and outlet.
D. Outer Casing: minimu 0.0598-inch thick steel with heat-resistant, baked-enamel finish over corrosion-resistant-treated surface in color to match fan section.
E. Inner Casing:

1. Burner Section Inner Casing: 0.0299-inch ((0.759-mm)) steel.
2. Double-wall casing with inner wall of solid steel, for the following sections:

    a. Blower section.
    b. Filter section.
    c. Mixing box.
    d. Inlet plenum.
    e. Discharge plenum.
    f. Access Doors: Piano hinged with cam-lock fasteners for burner and fan motor assemblies on both sides of unit.

3. Internal Insulation: Fibrous-glass duct lining, neoprene coated, comply with ASTM C 1071, Type II, applied on burner and fan sections only.

    a. Thickness: 2 inches (50 mm).
    b. Insulation Adhesive: Comply with ASTM C 916, Type I.
    c. Density: 1.5 lb/cu. ft. ((24.0 kg/cu. m)).
    d. Mechanical Fasteners: Galvanized steel suitable for adhesive, mechanical, or welding attachment to casing without damaging liner when applied as recommended by manufacturer and without causing air leakage.

F. Discharge Section: Galvanized or Aluminized-steel assembly.
G. Discharge Section: Trapezoidal cowls with horizontal louvers.
H. Casing Internal Insulation and Adhesive:

1. Materials: ASTM C 1071, Type I.
2. Location and Application: Factory applied with adhesive and mechanical fasteners to the internal surface of section panels downstream from, and including, the heating-coil section.

a. Liner Adhesive: Comply with ASTM C 916, Type I.
b. Mechanical Fasteners: Galvanized steel, suitable for adhesive, mechanical, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
c. Liner materials applied in this location shall have airstream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric, depending on service-air velocity.

3. Location and Application: Encased between outside and inside casing.

I. Inspection and Access Panels and Access Doors:

1. Panel and Door Fabrication: Formed and reinforced, single- or double-wall and insulated panels of same materials and thicknesses as casing.
2. Inspection and Access Panels:

a. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
b. Gasket: Neoprene, applied around entire perimeters of panel frames.
c. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.

3. Access Doors:

a. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
b. Gasket: Neoprene, applied around entire perimeters of panel frames.
c. Fabricate windows in [fan section]doors of double-glazed, wire-reinforced safety glass with an air space between panes and sealed with interior and exterior rubber seals.
d. Size: At least 18 inches wide by full height of unit casing up to a maximum height of 72 inches (1800 mm).

4. Locations and Applications:

a. Fan Section: Doors.
b. Access Section: Doors.
c. Burner Section: Inspection and access panels.

2.04 SUPPLY-AIR FAN

A. Fan Type: Centrifugal, rated according to AMCA 210; statically and dynamically balanced, galvanized steel; mounted on solid-steel shaft with heavy-duty[, self-aligning, permanently lubricated ball bearings or pillow-block bearings rated for L50 or 200,000 hours with external grease fittings.
B. Drive: V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly.
C. Mounting: Fan wheel, motor, and drives shall be mounted in fan casing with spring isolators.
D. Fan-Shaft Lubrication Lines: Extended to a location outside the casing.

2.05 INDIRECT-FIRED GAS BURNER

A. Description: Factory assembled, piped, and wired; and complying with ANSI Z21.47, "Gas-Fired Central Furnaces," and with NFPA 54, "National Fuel Gas Code."

1. CSA Approval: Designed and certified by and bearing label of CSA.
2. Burners: Stainless steel.
   a. Gas Control Valve: Modulating.
   b. Fuel: Natural gas.
   c. Minimum Combustion Efficiency: 80 percent.
   d. Ignition: Electronically controlled electric spark with flame sensor.

B. Venting: Power vented, with integral, motorized centrifugal fan interlocked with gas valve.
C. Combustion-Air Intake: Separate combustion-air intake and vent terminal assembly.
D. Heat Exchanger: Stainless steel.
E. Heat-Exchanger Drain Pan: Stainless steel.
F. Safety Controls:

1. Vent Flow Verification: Differential pressure switch to verify open vent.
2. Control Transformer: 24-V ac.
3. High Limit: Thermal switch or fuse to stop burner.
4. Gas Train: Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, electronic-modulating temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
5. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
6. Gas Manifold: Safety switches and controls complying with ANSI standards and FM Global.
7. Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.
8. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
9. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.

2.06 UNIT CONTROL PANEL

A. Factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel.
B. Control Panel: Surface-mounted remote panel, with engraved plastic cover, and the following lights and switches:

1. On-off-auto fan switch.
2. Heat-vent-off switch.
3. Supply-fan operation indicating light.
4. Heating operation indicating light.
5. Thermostat.
6. Damper position potentiometer.
7. Dirty-filter indicating light operated by unit-mounted differential pressure switch.
8. Safety-lockout indicating light.
9. Enclosure: NEMA 250, Type 1.

2.07 CONTROLS

A. Comply with requirements indicated on the drawings.

B. Control Devices:

1. Remote Thermostat: Adjustable room thermostat with temperature readout.
2. Timers: Solid-state, programmable time control with four separate programs; 24-hour battery carryover; individual on-off-auto switches for each program; 365-day calendar with 20 programmable holidays; choice of fail-safe operation for each program; and system fault alarm.
3. Ionization-Type Smoke Detectors: 24-V dc, nominal; self-restoring; plug-in arrangement; integral visual-indicating light; sensitivity that can be tested and adjusted in place after installation; integral addressable module; remote controllability; responsive to both visible and invisible products of combustion; self-compensating for changes in environmental conditions.

C. Fan Control: Timer starts and stops indirect-fired heating and ventilating unit and exhaust fan(s).

1. Smoke detectors, located in supply air, shall stop fans when the presence of smoke is detected.

D. Temperature Control: Operates gas valve to maintain supply-air temperature.

1. Operates gas valve to maintain space temperature with wall-mounted, field-wired sensor with temperature adjustment, and unit-mounted control adjustment.
2. Timer shall select remote setback thermostat to maintain space temperature at 60 deg F.
3. Burner Control: Two or four steps of control using one or two burner sections in series.

E. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display status and alarms of heating and ventilating unit.

1. Hardwired Points:

a. Room temperature.
b. Discharge-air temperature.
c. Burner operating.

2. ASHRAE 135.1 (BACnet) or Industry-accepted, open-protocol communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely control and monitor the heating and ventilating unit from an operator workstation. Control features and monitoring points displayed locally at heating and ventilating unit control panel shall be available through the DDC system for HVAC.

2.08 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure: Totally enclosed, fan cooled.
2. Enclosure Materials: Cast iron.
3. Efficiency: Premium efficient.

2.09 CAPACITIES AND CHARACTERISTICS: As shown on the drawings

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of indirect-fired heating and ventilating units.
B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.
C. Verify cleanliness of airflow path to include inner-casing surfaces, filters, coils, turning vanes, fan wheels, and other components.
D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Equipment Mounting:

1. Comply with requirements for vibration isolation and seismic control devices specified herein.

B. Unit Support: Install heating and ventilating unit level on structural bases or concrete pads as shown on the drawings.
C. Install gas-fired units according to NFPA 54, "National Fuel Gas Code."
D. Install controls and equipment shipped by manufacturer for field installation with indirect-fired heating and ventilating units.

3.03 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Connect gas piping with shutoff valve and union and with sufficient clearance for burner removal and service. Make final connections of gas piping to unit with corrugated, stainless-steel tubing flexible connectors complying with ANSI LC 1/CSA 6.26 equipment connections.

B. Drain: Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for traps and accessories on piping connections to condensate drain pans under condensing heat exchangers.
C. Where installing piping adjacent to heating and ventilating units, allow space for service and maintenance.
D. Ground equipment according to Section 342148 “Substation Grounding."

E. Connect wiring according to Section 341265 “Basic Electrical Materials and Methods."

3.04 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
B. Perform tests and inspections with the assistance of a factory-authorized service representative.
C. Units will be considered defective if they do not pass tests and inspections.
D. Prepare test and inspection reports.

3.05 STARTUP SERVICE

A. Perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
      a. Inspect for visible damage to burner combustion chamber.
      b. Inspect casing insulation for integrity, moisture content, and adhesion.
      c. Verify that clearances have been provided for servicing.
      d. Verify that controls are connected and operable.
      e. Purge gas line.
      f. Inspect and adjust vibration isolators.
      g. Verify bearing lubrication.
      h. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
      i. Adjust fan belts to proper alignment and tension.
      j. Start unit according to manufacturer's written instructions.
   2. Complete startup sheets and attach copy with Contractor's startup report.
   3. Inspect and record performance of interlocks and protective devices; verify sequences.
   4. Operate unit for run-in period recommended by manufacturer.
   5. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:
      a. Measure gas pressure at manifold.
      b. Measure combustion-air temperature at inlet to combustion chamber.
      c. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
   6. Calibrate thermostats.
   7. Adjust and inspect high-temperature limits.
   8. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.
   9. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
   10. Measure and record airflow. Plot fan volumes on fan curve.
   11. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:
      a. High-limit heat.
      b. Alarms.
   12. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.
   13. Verify drain-pan performance.
   14. Verify outdoor-air damper operation.

3.06 ADJUSTING

A. Adjust initial temperature set points.
B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
C. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.07 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain heating and ventilating units.

END OF SECTION

SECTION 23 83 13
ELECTRIC HEAT TRACING SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. This Section specifies the furnishing and installing of electric heat trace systems for protecting water pipes and drains from freezing.

B. The Contractor shall furnish and install complete and functional heat trace systems including wiring; controls; thermostats; all electrical connections and any conduit, cable, boxes, outlets and other equipment and accessories required.

C. Related work specified elsewhere:

1. Section 22 07 00, Mechanical Insulation.
2. Section 22 40 00 Plumbing
3. Section 23 00 00 Heating, Ventilation and Air Conditioning

1.02 SUBMITTALS

A. The Contractor shall prepare and submit, before fabrication and assembly of the heat trace system equipment, the following:

1. Shop drawings showing the layout of each pipe line to be protected, equipment drawings showing the details of the wiring, thermostat, controls, connections, warning lights and alarms and control panels.
3. Calculation data showing the electrical load data for each system.
4. Product data, catalog cuts and specifications describing the electrical and physical characteristics of each item including the thermostat, controls warning lights and alarms and control panels.
5. Installation instructions for the system.
6. Sample materials

B. The Contractor shall submit, for record and distribution, prior to shipment of the equipment, five copies of Operation and Maintenance manuals for the heat trace system.

1. Operation and Maintenance manuals shall include descriptive bulletins and operation leaflets for the thermostats, controls and warning lights and alarms.

   a. Each Operation and Maintenance manual shall contain the "Record Document" Drawings, complete operating and instruction manuals, spare parts lists, certified test documents, and other special data required for this equipment.

2. Spare parts bulletins shall be included with catalog cuts for each item.
3. Certified test reports shall include all assembly and subassembly test and inspection reports.

PART 2 PRODUCTS

2.01 GENERAL

A. The Contractor shall furnish all necessary labor and tools, materials, and equipment and shall properly construct and connect the electric heat trace system in accordance with the manufacturer's directions and recommendations.

B. The electric heat trace cable shall be either be covered with a protective nickel braid or covered with a tinned copper braid and a corrosion protective outer fluoropolymer jacket.

C. The Contractor shall coordinate the design and installation of the heat trace system with the pipe insulation system.

D. The design, selection and size of the heat trace cable shall be in accordance with correct heat transfer calculations as recommended by the equipment manufactures design guide.

E. The system shall be controlled and monitored from a single control panel. The system shall be controlled from a thermostat with provisions for a manual override from a Hand-Off-Auto switch.

F. Monitoring and alarm circuits shall be provided that monitor each heat trace circuit for current and continuity of the heat trace cable, and the entire system for low temperature failure.

G. The electric heat trace cable, control panel, and accessories shall have UL, FM, or CSA system listing.

2.02 MATERIALS

A. The Contractor shall furnish and install the electric heat trace system which shall include but not be limited to the electric heat trace cable, tape or banding, thermostats, control panel and warning lights and alarm.

B. The electric heat trace system for freeze protection shall be controlled from a common ambient sensing thermostat set to activate the system at 40 degrees, and a parallel backup thermostat set at 40 degrees F. An alarm shall be provided to indicate the failure of either thermostat or lack of power.

C. The control panel shall provide for the necessary controls and contactors plus an additional 25 percent spare space. The contactors shall be electrically operated, electrically held, 30 ampere, 600 Volt, 3 pole, with a 120 Volt control coil. The contactors shall be as manufactured by Allen Bradley or Square D.

D. LED pilot lights shall be provided to indicate control power available, system on, off, and circuit on and failure alarms for each heat trace circuit.

E. The system and all components shall be approved by the Authority.

F. The cable shall be industrial type, rated 8 watts per foot (W/ft), at 120 volts, at a temperature of 50 degrees F. and a temperature identification number (T-rating) of T6 (185 degrees F. exposure). Values shall be established per Institute of Electrical and Electronics Engineers, Incorporated (IEEE) Standard 515, Testing, Design, Installation and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications.

G. The heating cable shall be self-regulating. The cable heat output shall decrease with raising ambient temperature without employment of an auxiliary electrical regulatory device.

H. The heating cable shall be composed of two parallel 16 AWG (or larger) stranded, nickel-plated copper bus wires, embedded in a polymeric conductive (heat generative) core (web). The wires and core shall be enclosed within a tinned copper, braided shield, suitable for use as an electrical fault grounding conductor. All cable components shall be jacketed with a tough, abrasion and moisture resistant thermoplastic (e.g. polyolefin), inert with aqueous and cleaning chemicals. The overjacket shall provide corrosion protection for the cable. A polyolefin or fluoropolymer overjacket is an acceptable alternate.

I. The cable shall have, monitor wires and a tinned copper braid, with a fluoropolymer jacket for mechanical and corrosion protection. The cable is suitable for direct placement on metallic and polyvinyl chloride (PVC) piping. The heat trace circuits shall be designed to operate on 20 ampere circuits.

J. The heating cable shall be unaffected by exposure to non-hazardous, unshielded indoor and outdoor environmental conditions. The cable service life shall not be diminished by exposure to ultraviolet radiation and random fluctuating temperatures within the range of -30 degrees to 150 degrees F.

K. The cable shall have a minimum expected service life of 10 years in applications of continuous operation. A minimum of 90% of the nominal rated power shall be exhibited following 1000 hours of continuous operation, in accordance with Underwriters Laboratories, Incorporated (UL) Standard 746B, Polymeric Materials – Long Term Property Evaluations.

L. Heating cable shall be UL approved. Cable shall have original manufacturer's labeling.

M. The heat trace system shall be as manufactured by Delta-Therm, Chemelex, Bylin or approved equal.

PART 3 EXECUTION

3.01 PREPARATION

A. Heat tracing shall be installed on clean surfaces free of dirt, debris, protrusions, oil, grease and moisture. Remove existing insulation, if any, as required for proper installation of the heat trace cable. Remove existing heat trace system or components as required for installation of the new system or components.

B. Locations for installation of the control panel, thermostat and warning light and alarm shall be approved by the Authority.

3.02 INSTALLATION

A. The heat trace cable shall be installed in such a manner as to maintain the best possible contact with the traced pipe, valves, flanges and other in-line equipment. The heat tracing cable shall be secured to the pipe as recommended by the heat trace system manufactures installation instructions.

B. In order to allow for maintenance access to valves, strainers, and other in-line equipment where additional heat tracing is required, a loose loop of heating cable of the length required shall be left at the item to be traced. The loop shall be spiraled around the item and secured as recommended by the heat tracing system manufacture's installation instructions.

C. All junction boxes, splices, and terminations requiring maintenance shall be mounted to be accessible without disturbing the insulation and jacket.

D. The location of the ambient sensing thermostats shall be selected to obtain a representative temperature, be accessible for maintenance, and protected from tampering.

E. The installation and final adjustments to the electrical heat tracing system shall be supervised and field tested by a qualified factory trained equipment manufactures service engineer.

F. After field testing has been completed the installed heat trace system shall be covered with insulation and a jacket as specified in pipe insulation section of this Specification.

G. All pipe electrically heat traced and insulated shall have a plastic label applied to the insulation every 25 feet. The plastic label shall read "Electric Heat Trace Circuit Number, Panel Number.

H. Unless otherwise approved, cable of 1000 feet in length and shorter shall be furnished in one piece. Cable of greater lengths shall be furnished in increments of this length or longer.

3.03 ELECTRICAL CONNECTIONS

A. Final electrical connections between the heat trace system and the power source and the energizing of the system will be performed by the Authority's electrical department unless directed and approved otherwise.

3.04 RE-INSULATION

A. Re-insulate or insulate over the new heat trace cable after installation. See insulation specification. Type of insulation must be approved to be used with the heat trace cable to avoid fire and other hazards. Insulate according to manufacturer's directions. Take precautions to not damage the heat trace cable.

3.05 OPERATION AND MAINTENANCE MANUAL

A. Upon completion, Contractor shall test system for proper operation and set controls.

B. The equipment manufacturer and installer shall provide adequate training for the Authority's Personnel in the proper operation and maintenance of the equipment.

C. The installer shall provide as built drawings indicating the location of heat tracing and location of connections, controls, thermostats and warning lights and alarms. The manufacturer shall provide final and complete operation and maintenance manuals for all components of the heat trace system.

3.05 PROTECTION

A. Protect installed heating cables, including nonheating leads, from damage during construction.

B. Remove and replace damaged heat-tracing cables.

3.06 TESTING, BALANCING AND COMMISSIONING

A. Upon completion of installation and after building circuitry has been energized, test, balance and commission the system to demonstrate operability and compliance with requirements as per equipment schedule. Where possible, field correct malfunctioning units, then retest to demonstrate compliance.

B. Submit test sheets for records and documentation.

END OF SECTION

SECTION 23 83 33
RADIANT HEATING UNITS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes the following:

1. Electric radiant heaters.

1.03 SUBMITTALS

A. Product Data: Include rated capacities, materials and specification sheets, UL approval certificate, specialties, and accessories for each product indicated.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work. Include rough opening dimensions and other opening requirements for recessed and semi-recessed units. Detail equipment assemblies and attachment. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Operation and Maintenance Data: For electric radiant heaters to include in operation, and maintenance manuals.

1.04 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. All electric heaters to be U.L. approved and NEC standards.

C. Field quality-control reports.

D. Sample Warranty: For special warranty.

1.05 COORDINATION

A. Coordinate layout and installation of radiant heaters and components with other construction.

B. Coordination Drawings: Reflected ceiling plans and floor plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Structural members to which heating panels and suspension systems will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Items installed in finished ceiling, including the following:

   a. Lighting fixtures.
   b. Air outlets and inlets.
   c. Speakers.
   d. Sprinklers.
   e. Access panels.
   f. Perimeter moldings.
   g. Smoke, CO_2 detectors, etc.
   h. Electrical outlets

1.06 ELECTRIC RADIANT HEATERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Berko Electric Heating; a division of Marley Engineered Products.
2. Trane Co.
3. Chromalox Inc.; a division of Emerson Electric Company.
4. Fostoria Industries, Inc.; a division of TPI Corporation.
5. Markel Products; a division of TPI Corporation.
6. Omega Engineering, Inc.
7. QMark Electric Heating; a division of Marley Engineered Products.
8. Approved equal.

B. Units to be UL approved.

C. Enclosures: Painted steel housing with anodized-aluminum reflector.

1. Finish: Baked-enamel finish in manufacturer's standard paint color as selected by Architect.

D. Unit Controls:

1. See electrical drawings for control schemes.

E. Capacities and Characteristics: See schedules and drawings

1.07 FAN-FORCED ELECTRIC WALL HEATER

A. Electric semi-recessed wall mounted thermostat controlled with fan and built-in fan delay switch to energize fan motor after elements are heated and shuts off fan motor when residual heat has been dissipated after heat shuts off.

1. Fan motor to have lifetime lubricated bearings.
2. Heater to have a power disconnect switch and be equipped with a thermal overheat protection in the event of overheating.
3. Heater to have an integral built-in thermostat; adjustable at front cover.

B. Enclosure: Semi-recessed housing to be 20 gauge minimum galvanized metal. Front cover and grill to have a neutral gray baked enamel finish.

C. Heating elements to be steel finned metal sheath.

D. The wall mounted electric heater for this project shall be Trane UHAA series, or another manufacturer's model submitted to the Authority for approval as an equal.

PART 2 - EXECUTION

2.01 EXAMINATION

A. Examine areas to receive radiant heating and cooling units for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for electrical connections to verify actual locations before radiant heating unit installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

2.02 INSTALLATION

A. Install radiant heating and cooling units level and plumb.

B. Verify that size of opening for semi-recessed wall heater is of proper size and depth for proper installation of the heater. Follow manufacturer's directions and installation drawings.

C. Install wall heaters at locations indicated on the drawings. Verify sizes and conditions in the field. Install wall heater at height from floor recommended by manufacturer.

D. Secure heaters to wall as recommended by manufacturer, using approved fasteners required to secure heaters to the specific substrate.

2.03 CONNECTIONS

A. Ground electric units according to Section 342148 "Substation Grounding."

B. Connect wiring according to Section 342165 "Basic Electrical Materials and Methods."

2.04 FIELD QUALITY CONTROL

A. Testing: Perform the following field tests and inspections and prepare test reports:

1. Operate electric heating elements through each stage to verify proper operation and electrical connections.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and units.

B. Remove and replace malfunctioning units and retest as specified above.

C. After installing panels, inspect unit cabinet for damage to finish. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

2.5 TESTING, BALANCING AND COMMISSIONING

A. Upon completion of installation and after building circuitry has been energized, test, balance and commission the system to demonstrate operability and compliance with requirements as per equipment schedule. Field correct malfunctioning units, then retest to demonstrate compliance.

B. Submit test sheets for records and documentation.

END OF SECTION

SECTION 26 03 00
ELECTRICAL DEMOLITION

PART 1 GENERAL

1.01. RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Special Conditions and Division 01 Specification Sections, apply to this section. 29 CFR 1926 Sub Part K shall also apply to this section.

1.02. SUMMARY

A. Work required for this Section includes providing all labor, material, apparatus, equipment and services necessary to disconnect , remove, delivery, and storage of electrical and traction power items which are affected by or rendered obsolete by demolition work.

B. Major items with all related appurtenances, which are rendered obsolete and require removal in the areas being demolished, include but are not limited to, the following:

1. Service equipment.
2. Lighting fixtures.
3. Wiring devices.
4. Conduits and raceways.
5. Outlet boxes.
6. Wire and cable from source to point of use.
7. Light Poles.
8. Other accessories, brackets and other items as required to facilitate the installation of the new fixtures or equipment; damaged or no longer required for the new installations.
9. Traction power equipment including but not limited to rectifier transformers, auxiliary power transformers, silicon rectifiers, ac switchgear assemblies, dc switchgear assemblies, anode bus ducts, negative equalizer buses and drainage boards, station batteries, battery chargers dc distribution panel boards for 125 volt dc control power, relays, transfer switches, ac distribution panel boards, getaway switches, getaway cables interconnected power and control cables interconnected between the traction power equipment and related appurtenances
10. SCADA RTU’s as noted on the drawings.

C. Communications equipment throughout the building shall remain and shall be protected during demolition unless otherwise noted on the drawings.

D. Care should be taken to not damage existing surfaces, wiring and other items needed for the new installations.

E. All material, equipment, damaged items; conduit and wire rendered obsolete shall be removed from the premises and properly disposed of off-site by the Contractor.

F. Items being removed which are salvageable and serviceable (such as major traction power equipment, lighting fixtures, wiring devices, signal and telecommunication devices) shall remain the property of the Authority and shall be stored by the Contractor in locations on site where directed by the Authority. Items of doubtful classification shall be reviewed with the Authority's representative prior to disposal of same to determine their disposition. Care shall be exercised in the removal of these items to avoid damage.

G. Relocation and/or modifications to certain existing equipment may be required to retain services to existing adjacent systems or equipment which are to remain. Such relocation and/or modification costs are to be included in the Base Bid and no additional compensation will be allowed.

H. Include providing new conduit, wiring, boxes, outlets, fittings, etc. as may be required for such relocation and retention of services.

I. Existing conduits concealed in slabs which are rendered obsolete shall be cut off flush with the surfaces and plugged with foam. Foam sealant shall be as manufactured by G.E., Dow or 3M unless otherwise specified on the drawings.

J. Existing recessed boxes in concrete columns or walls which are to remain shall be filled with foam and provided with suitable blank covers. Foam sealant shall be as manufactured by G.E., Dow or 3M.

K. The areas currently occupied must remain operational at all times unless approved otherwise. Coordinate any construction and/or staging activities that may impede normal CTA operations with the Authority including, but not limited to, any activity that generates excessive noise or airborne dust; interference with the Authority's operations; access or use by the Authority's customers or public; or the safety of employees, customers or the public. The Contractor shall schedule the access to the work, use of the facility and other issues pertaining to the demolition and construction with the Authority to minimize disruption to the Authority's operations and protect other areas of the building from damage and allow for safe passage of personnel.

L. Provide safety protection system around work area to protect pedestrians, vehicles, customers and CTA personnel.

M. Contractor to provide a staging plan and safety plan for the Authority's approval prior to starting the work. Coordinate with the Authority for staging areas.

N. Contractor shall schedule and coordinate all work with the Authority. Contractor shall submit and obtain approval on a process plan and phasing plan for all the work, including demolition prior to commencing work on site.

O. Contractor to refer to and adhere to the Drawings, Specifications and other documents provided for this Project.

P. Work may include patching and repairs to existing adjacent surfaces after removal or demolition. Work includes coring and cutting existing surfaces for installation of new plumbing piping and electrical conduit. Patch upon completion. Patching and repairs to match existing materials and finishes.

Q. Related work specified elsewhere:

1. Division 01 Section "Summary of Work".

2. Division 01 Section "Cutting and Patching" for cutting and patching procedures for selective demolition operations.

3. Section 26 50 10 Lighting Fixtures

4. Section 34 21 01 General Requirements for Traction Power Equipment

5. Section 34 21 03 Traction Power Rectifier Equipment

6. Section 34 21 04 Traction Power 600 Volt DC Silicon Rectifier

7. Section 34 21 05 Traction Power 800 Volt DC Switchgear

8. Section 34 21 06 Traction Power Anode Bus Duct

9. Section 34 21 07 Traction Power Substation Batteries And Associated Accessories

10. Section 34 21 08 Traction Power DC Distribution Panel

11. Section 34 21 19 Traction Power 15 KV AC Switchgear

12. Section 34 21 25 Traction Power Cables

13. Section 34 21 27 Service And Distribution (600 Volt AC and Below)

14. Section 34 21 40 Traction Power DC Disconnect (knife) Switches

15. Section 34 21 48 Substation Grounding

16. Section 34 21 49 Traction Power Substation Dielectric Flooring

17. Section 34 21 61 General Provisions Traction Power

18. Section 34 21 65 Basic Electricals Materials and Methods Traction Power

19. Section 34 21 68 Traction Power Underground Duct and Manhole

20. Section 34 21 90 Traction Power Substation Controls

21. Section 34 24 20 Traction Power Contact Rail

22. Section 34 24 22 Contact Rail Insulated Chairs – Fiberglass

23. Section 34 24 25 Traction Power Contact Rail Heaters

24. Section 34 24 40 Auxiliary Negative Cables

1.03. DEFINITIONS

A. Remove: Remove and legally dispose of items except those indicated to be reinstalled, salvaged, or to remain the Authority's property.

B. Remove and Salvage for Recycling: Items indicated to be removed and recycled are to be separated and arranged for recycling. Construction debris from demolition and construction waste materials are to be picked up by recycling waste haulers for recycling to the greatest extent possible. As a minimum requirement, the Contractor to follow the City of Chicago Ordinance for recycling construction debris.

C. Remove and Salvage for Re-use: Items indicated to be removed and salvaged remain the Authority's property. Remove, clean, and pack or crate items to protect against damage. Identify contents of containers and deliver to Authority's designated storage area.

D. Remove and Reinstall: Remove items indicated; clean, service, and otherwise prepare them for reuse; store and protect against damage. Reinstall items in the same locations or in locations indicated.

E. Existing to Remain: Protect construction indicated to remain against damage and soiling during selective demolition. When permitted by the Authority, items may be removed to a suitable, protected storage location during selective demolition and then cleaned and reinstalled in their original locations.

1.04. MATERIALS OWNERSHIP

A. Except for items or materials indicated to be reused, salvaged for re-use, reinstalled, or otherwise indicated to remain the Authority's property, demolished materials shall become the Contractor's property and shall be removed from the site and legally disposed of by the Contractor.

1.05. SUBMITTALS

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

1. Schedule of demolition activities indicating the following:

   a. For each location: Detailed sequence of demolition and removal work, with starting and ending dates for each activity.
   b. Interruption of utility services.
   c. Coordination for shutoff, capping, and continuation of utility services.
   d. Detailed sequence of selective demolition and removal work to ensure uninterrupted progress of Authority's on-site operations.
   e. Locations of temporary partitions, barriers and means of egress.
   f. Foot traffic control or interruption. Closing of areas.
   g. Indicate how demolition work will avoid interruption of Authority's on-site operations.

2. Proposed recycling procedures.
3. Inventory of items to be removed and salvaged for re-use.

B. Provide written and dated documentation of the total amount of each different waste material, the amount of each sent to a recycling facility and the amount of each sent to a landfill. Documentation shall be done on a daily basis. Indicate when and who the materials were picked up by and the name of the recycling facility the materials were sent to.

1.06. QUALITY ASSURANCE

A. Regulatory Requirements: Comply with governing EPA notification regulations before starting selective demolition. Comply with hauling and disposal regulations of authorities having jurisdiction. Comply with City of Chicago Recycling Ordinance.

1.07. PROJECT CONDITIONS

A. Contractor required to survey existing conditions to verify all existing dimensions and conditions, locations of items and construction sizes of items and including conditions and limitations under which he is to do his work.

B. Contractor required locating all existing utilities and other improvements, including utilities not exposed to view.

C. There will be no extras allowed to compensate Contractor for his failure to review and verify existing conditions and dimensions.

D. Demolition work to adhere to phasing plans for the project.

E. Work may include patching and repairs to existing adjacent surfaces after removal or demolition. Patching and repairs to match existing materials and finishes.

1.08. DELIVERY HANDLING AND MATERIAL STORAGE

A. Any areas or facilities used by the Contractor for storage of materials to be delivered to the Authority shall be climate controlled, and secured dry locations off the ground. Relative humidity shall not exceed 70 percent.

B. All materials shall be delivered to the location specified by the authority. The contractor shall provide all labor, tools, and material handling equipment needed to safely deliver the equipment to Authority’s location.

C. Follow manufactures guidelines for delivery and storage of equipment. Care should be taken to not damage any of the equipment or components. Contractor shall provide all packaging required to protect the equipment during delivery and storage.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01. SPECIAL CONDITIONS

A. Visit the Project Site and thoroughly investigate existing conditions. Carefully evaluate all existing Electrical Work which is to be removed, altered or modified, and include all these costs in the Bid. Determine existing installation Work which is to remain to serve areas outside the limits of demolition Work and include all costs of relocation Work which may be required to retain these services. No additional costs will be allowed for failure to include all labor and material that is required for demolition, relocation or modification to the existing electrical installation. If any potential problems are envisioned during the site visit which could affect the Work to be done, they shall be brought to the immediate attention of the Authority.

B. Electrical demolition shall be done according to the schedule established for general demolition work to eliminate any conflicts, interferences or delays.

C. Exercise care in demolition work so as not to damage or interrupt existing services which may pass through the areas of demolition and serve areas outside the demolition work areas which are to remain.

D. Provide adequate temporary services as may be required including standby generators if deemed necessary.

3.02. ENVIRONMENTAL

A. Equipment containing asbestos, lead, and PCB's shall be properly disposed based on Environmental Protection Agency (EPA) guidelines and CTA hazardous material abatement specifications.

B. Existing light fixtures, bulbs and other items to be discarded shall be disposed of by the Contractor strictly according to all applicable regulations, including the Environmental Protection Agency (EPA) requirements.

1. Luminaires containing mercury, mercury vapor, sodium or other potential harmful substance shall be handled, transported and disposed of as special waste following EPA guidelines and regulations. Special waste shall be disposed of only at the Authority's approved waste facilities and proper manifests shall be executed and submitted to the Authority upon completion.

3.03. UTILITY SERVICES

A. Maintain existing utilities indicated to remain in service and protect them against damage during selective demolition operations.

1. Do not interrupt existing utilities serving occupied or operating facilities, except when authorized in writing by Authority and authorities having jurisdiction. Provide temporary services during interruptions to existing utilities, as acceptable to Authority and to governing authorities.

a. Provide not less than 72 hours' notice to Authority if shutdown of service is required during changeover.

3.04. PREPARATION

A. Conduct demolition operations and remove debris to ensure minimum interference with adjacent occupied and used facilities.

1. Do not close or obstruct adjacent occupied or used facilities without permission from Authority and authorities having jurisdiction. Provide alternate routes around closed or obstructed foot traffic ways.

2. Do not block required exits or stairways.

B. Conduct demolition operations to prevent injury to people and damage to adjacent facilities to remain. Ensure safe passage of people around selective demolition area.

3.05. DEMOLITION

A. Demolition of traction power equipment shall be performed in stages as described in the plans and herein the Specification. The Contractor shall remove and dispose, all 15 KV ac incoming cables, 15kv ac switchgear assemblies, rectifier transformers, rectifiers anode bus ducts dc switchgear assemblies, getaway cables, batteries and battery chargers ac and dc auxiliary equipment as noted on the drawings.

B. Wall Mounted Light Fixtures: Existing wall mounted light fixtures shall be completely removed. Remove fixtures without damaging the wall or other adjacent surfaces or construction. Disconnect from wiring carefully to avoid damaging the wiring and to facilitate installation, connection and operation of replacement light fixtures. Remove existing anchors, patch holes and perform other repairs as required to facilitate installation of the replacement fixture and provide for surfaces to align and match the existing adjacent surfaces.

C. Pole Mounted Light Fixtures: Existing pole mounted light fixtures shall be completely removed. Remove fixtures and fixture arms as required without damaging the existing poles. Disconnect from wiring carefully to avoid damaging the wiring and to facilitate installation, connection and operation of replacement light fixtures. Remove existing anchors, fixture arms and other items to facilitate the installation of the replacement fixtures. Perform repairs as required to facilitate installation of the replacement fixture and provide for proper installation of the new luminaires. Where indicated or required, cut down the height of the existing poles for optimum operation of the new luminaires. Provide and install accessories as required for proper and secure installation of the new fixtures including, but not limited to, new brackets, bolts, pole caps, etc.

1. Verify the structural integrity of each pole installation before and after alterations and installation of the new light pole head fixtures.

D. Properly dispose of demolished items and materials promptly. On-site storage or sale of removed items is prohibited.

E. Repairs, patching and replacements due to damage by the Contractor are the complete responsibility of the Contractor.

END OF SECTION

SECTION 26 50 10
LIGHTING FIXTURES

PART 1 GENERAL

1.01. RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02. SUMMARY

A. This Section specifies the methods of construction and installation that apply to lighting fixtures, exit lights, emergency lights, motion sensor switches, and accessories required for a complete interior and exterior lighting system.

B. Related work specified elsewhere:

1. Section 26 03 00 Electrical Demolition.
2. Section 26 95 00 Electrical Testing
3. Section 34 21 27 Service and Distribution (600 V AC and Below)
4. Section 34 21 48 Substation Grounding
5. Section 34 21 61 General Provisions Traction Power
6. Section 34 21 65 Basic Electrical Materials and Methods – Traction Power
7. Section 34 21 90 Traction Power Substation Controls

C. The Contractor shall furnish and install all lighting fixtures as shown on the Drawings and indicated on the light fixture schedule.

D. All fixtures shall have NRTL label or listing.

E. Fixture catalog numbers specify the standard of quality and appearance required and shall represent the basic fixture of that type. Substitutions to the listed acceptable manufactures will not be accepted until the contractor has complied with the requirements of Section 01 33 00, Submittal Procedures.

F. Lamps, mounting brackets and mounting hardware for all fixtures shall be supplied by the Contractor.

G. LED light sources and power supplies shall be supplied by the approved manufacturer.

1.03. SUBMITTALS

A. Submit the following according to the requirements of the general conditions and Division one submittal section of these specifications:

1. Product Data for each fixture type, each lamp type, accessories, brackets and poles.

2. Specifications and technical data for each fixture showing light output and range, electrical data, specifications for lamps and lens, specifications for brackets, arms, and poles.

3. Shop drawings for each fixture type including showing lamp replacement access, bracket, installation and attachment details. Shop drawings of pole, arms, base plate, etc.

4. Connection diagrams for the wiring of equipment shall be included.

5. Engineering calculations for pole design and installation.

6. Warranty information for each fixture and accessory.

7. Maintenance information for each fixture, including recommended cleaning instructions.

B. Provide product overview data, applicable standards and certifications, catalog number order information, product selection information, technical data and specifications and installation support hardware information. Provide data with respect to approved use in classified hazardous locations. Contractor shall submit proposed product data for approval by the Authority. Luminaires shall include, but not be limited to, ceiling and wall mounted luminaires, pit luminaires and emergency lighting.

C. Prior to construction, Contractor to provide a temporary installation drawing for the Authority’s approval.

D. The Contractor shall submit, for record and distribution in accordance with the Division 01 Sections, Project Closeout, prior to shipment of the equipment, copies of Instruction, Operation and Maintenance manuals for all electrical fixtures and related items.

1. Operation and Maintenance manuals shall include descriptive bulletins and operation leaflets for the equipment.

   a. Each Instruction, Operation and Maintenance manual shall be in a three ring hard binder with tabbed sections. The binder cover shall have the project name and equipment name. The lettering shall be block type and shall be a minimum height of 1/2 inch.
   b. Each Instruction, Operation and Maintenance manual shall contain the "Record Document" Drawings, complete operating and instruction manuals, spare parts lists, certified test documents, and other special data required for this equipment.
   c. The "Record Document" Drawings larger than 8 1/2 inches by 11 inches shall be fan folded.

2. Spare parts bulletins shall be included with catalog cuts for each item.

3. Certified test reports shall include all assembly and subassembly test and inspection reports.

E. The Contractor shall submit shop drawings and other data sheets that were revised or modified during installation; in accordance with Division 01 Sections, Project Closeout. These will be inserted in the previously submitted instruction manuals.

F. Point by Point Calculations

1. Furnish point by point calculations for all areas illuminated by submitted fixtures. Calculations must be performed using 0.75 overall light loss factor (LLF) for interior and 0.80 overall LLF for exterior. Contractor must coordinate in the event area is being illuminated by more than one type of fixtures. Calculations shall be in compliance with CTA design criteria illumination levels.

2. Minimum illumination for the interior of the substation shall be 50 foot candles. Cable vaults shall have a minimum of 10 foot candles.

3. Maximum or minimum foot candles shall be within 25% of targeted foot candles listed in the Authority's Design Criteria.

G. See Section 34 21 61, General Provisions Traction Power for additional submittal requirements.

1.04. WARRANTY

A. Warranty Requirements for All Fixtures:

1. The fixture and all its components shall be warranted by the fixture manufacturer to be free from defects in material and workmanship for a period of one (1) year from the date of installation.

2. The Contractor shall agree to promptly correct by repair or replacement any defect or failure of compliance that may develop within one (1) year of the date of installation. Any part or material replaced under this warranty shall be warranted for additional one (1) year period from the date of replacement.

3. The Contractor's obligation shall include reimbursement to the Authority for any labor, material, transportation or reinstallation costs incurred by the Authority in making any correction assented to by the Contractor.

B. Additional Warranty Requirements for LED Fixtures:

1. The LED fixtures shall be warranted by the manufacturer for a period of ten (10) years against defects in materials and workmanship that result in a fixture lumen depreciation of 30 percent or greater. The maximum allowed lumen depreciation annually is 3%.

1.05. EXTRA MATERIALS

A. Contractor shall provide and deliver to the Authority a minimum of 10% attic stock of spare light source/lamps and power supply/ ballasts for each type of light fixture used for the project.

PART 2 PRODUCTS

2.01. GENERAL REQUIREMENTS

A. The Contractor shall furnish and install all lighting fixtures in strict accordance with the Lighting Fixture Schedule or Lighting Fixture Details as described hereunder or on the Drawings. Fixtures shall be complete with all necessary accessories and related work including lamp holders, lamps, ballasts/LED power supplies, starters, LED light sources, prismatic style lens, frames, support, wiring and all connections. The Contractor shall provide supports from framework where no finished ceiling occurs.

B. The Contractor shall provide auxiliary supports for mounting fixtures in areas without ceilings (i.e. exposed beams and joists) as may be required for proper installation of fixtures. Such supports shall span a minimum of 2 joists for each individual fixture, and shall be securely and suitable anchored to same. Fixtures shall not be supported from underside of roof deck or built tees except as specifically noted otherwise on the Drawings, the detail shall be followed.

C. The Contractor shall provide adequate protection for fixtures and at completion of the work they shall be clean and free of foreign material. Replace all burned out or defective components, until such time as the Authority takes complete occupancy of the facility.

D. All material furnished under this contract shall be new and of the best quality practicable for the application.

E. All fixtures shall be constructed to be sturdy and rigid.

F. Fixtures shall have a clean uncluttered appearance. There shall be a minimum of exposed hardware.

G. The fixture shall be so constructed, hinged and latched that re-lamping, ballast replacement, power supply replacement, and LED light source component replacement can be performed safely by one individual from a centrally located ladder, without requiring relocation of the ladder.

H. Fixtures shall be designed and tested to maintain the temperature of all interior components (ballasts, lamps, gaskets, diffusers, etc.) below their respective manufacturer’s recommended normal operating temperature.

I. Each fixture shall be assembled from material components in a careful manner by persons experienced in their line of work. Forming, assembly and subassembly shall be accomplished such that all parts come together in the fixture to form a complete, well fitted integrated assembly.

J. Conduit and wire entries to the fixture shall be through knock-outs provided by the fixture manufacturer on the top or end plate of the chassis, as specified in the project drawings. Entry shall be flush with the top of the fixture. All penetrations to the fixture shall be properly sealed. Field drilled holes shall be sealed with manufacturer supplied gasket.

K. The entire lens area of the fixture (exclusive of door frame members) shall be uniformly illuminated. There shall be no black or unlit areas including those areas where ballast, power supplies, or sockets are located.

L. Fixtures and luminaires must be manufactured in the United States and adhere to the ARRA Buy American Compliance Act.

M. Fixtures shall be designed with a 0.75 overall Light Loss Factor (LLF) for interior and 0.80 overall LLF for exterior, which includes the Lamp Lumen Depreciation (LLD), Luminaire Dirt Depreciation (LDD), and equipment factors.

2.02. POWER DISCONNECT FOR FIXTURES

A. Provide a power disconnect inside the fixture for the conductors supplying power to the fixture to facilitate easy removal of the ballast or LED power supply for maintenance and shall be prewired by the fixture manufacturer.

B. Disconnect shall be self-aligning (polarized) snap in type and shall contain three wires, one each for the hot, neutral and equipment ground conductor.

C. Male side of disconnect shall be connected to the ballast or LED power supply lead-in wires so that exposed contacts are dead in the disconnected position.

D. Disconnect shall be U.L. listed. The dielectric strength of the connector shall be 1500 volt minimum.

2.03. WIRING FOR FIXTURES

A. Wire inside fixtures shall be copper conductor of ampacity required plus twenty-five percent (25%) for continuous load.

B. Insulation shall be rated for 1000 volt AC and shall be rated for operation at 90 degrees C. in dry locations.

C. All connections inside the fixtures shall be made with materials rated for a minimum of 90 deg. C.

2.04. FUSE HOLDER AND FUSE FOR FIXTURES

A. Fuse holder shall have compact through-panel design and facilitate easy replacement of fuse.

B. Fuse Holder shall be rated for 30A, 600VAC.

C. Fuse Holder shall be NRTL (UL, CSA, or ETL) recognized.

D. Fuse shall be replaceable type and shall be properly rated to protect the fixture. .

2.05. FLUORESCENT LIGHT SOURCE FIXTURES

A. Fluorescent lamp fixtures four (4) feet in length shall be of the type as called for on the Light Fixture Schedule.

B. All auxiliaries used with fixture shall have NRTL labels.

C. Surface mounted fixtures shall have top reflector plates and shall be so designed so as to limit ballast case temperature to 90 degrees C.

D. Fluorescent Lamp Ballasts:

1. Provide electronic ballast for light fixtures rated to operate on 120 volt, 60 Hz circuits.

2. Ballast shall be securely affixed to the interior of the fixture so that it is not affected by vibrations.

3. The ballast shall carry the NRTL labels.

4. The ballasts shall be provided with integral leads, color coded to ANSI Standard C 82.11, latest version.

5. All ballasts for fluorescent fixture shall be specifically designed for cooler case and capacitor temperatures. Ballasts shall be premium grade class "P" as required by the National Electrical Code.

6. Ballast shall be rated for operation and startup at temperatures ranging from -30 to 50 degrees C

7. Ballast shall be mounted to a heat sink to facilitate removal of heat from fixture. Area of heat sink in contact with exterior metal of fixture shall be a minimum of twice the area of the ballast surface in contact with the heat sink.

8. Ballast and wiring connections shall be inside the fixture housing and shall be easily accessible for maintenance and removable.

9. Ballasts shall be automatic resetting type with individual capacitor protection.

10. Provide 800 MA high power factor electronic ballast for 6'-0" & 8'-0" long fixtures as indicated on the Drawings.

11. The "High Frequency" electronic ballast shall operate lamps at a frequency of 20 KHz or higher without visible flicker. The electronic ballast's input current shall have Total Harmonic Distortion (THD) of less than 20% when used with primary lamp. The electronic ballast shall have a Power Factor greater than 98% when used with primary lamp. The electronic ballast shall have Lamp Current Crest Factor of less than 1.7, in accordance with lamp manufacturers' recommendations and ANSI C 82.11. The electronic ballast shall support a sustained short to ground or open circuit of any output leads without damage to the ballast. The electronic ballast shall have an audible noise rating of Class A or better. The electronic ballast shall meet ANSI C 82.11 standards regarding harmonic distortion. Ballast shall meet ANSI C 62.41 Cat. A for transient protection. The electronic ballast shall comply with all applicable state and federal efficiency standards. The electronic ballast shall be Advance, Motorola or MagneTek or approved equal. The electronic ballast shall carry a five (5) year warranty. Manufacturer shall be a full line ballast manufacturer with a ten (10) year history of producing electronic ballasts for the North American Market.

12. Electronic ballasts shall maintain constant light output over operating ranges of 90 V. to 145 V.

13. Electronic ballasts shall withstand line transients as defined in ANSI/IEEE C 62.41 Cat. A., and meet the requirements of the Federal Communications Commission Rules and Regulations, Part 18, for non-consumer equipment.

2.06. LED LIGHT SOURCE FIXTURES

A. General:

1. LED Light Source Fixtures shall be of the type called for on the light fixture schedule.

2. The LED light source shall have a color temperature of 5000K and color rendering index (CRI) of 80 minimum.

3. Lumen depreciation shall be measured according to IESNA LM-80. Reported lumen maintenance shall be reported and calculated according to IESNA TM-21. Luminaire manufacturer shall report all lumen maintenance values using the EnergyStar TM-21 calculator. All photometric data shall be obtained from a NVLAP facility using IESNA LM-79.

4. Life/lumen maintenance shall provide greater than or equal to 70% of the initial lumens L70 at 100,000 hours. The maximum allowed lumen depreciation annually is 3%.

5. The fixtures shall be rated for operations at -30 to 50 degrees C.

6. The fixture efficacy shall not be less than 85 lumens/watt delivered.

7. The LED boards and driver shall not be mounted directly to the fixture housing, and shall be mounted with standard available hardware.

8. The LED chips used shall be manufactured by Samsung, Cree, Philips-Limited, or Nichia

9. The fixture shall be Design Lights consortium (DLC) listed, and RoHS compliant

10. Fixture shall have integral over- temperature protection which does not result in the fixture turning off but rather the reduction of drive current through dimming.

11. LED lighting components shall be nominal length as required to completely and uniformly fill the luminous opening of the fixture

B. LED Light Source Fixture Sub-Assembly:

1. Each LED Light Source Fixture sub-assembly shall be designed for easy field installation and maintenance. Sub-assembly shall consist of the following:

    a. LED board.
    b. Heat sink/chassis.
    c. Mounting plate.
    d. Power supply.
    e. Fuse.

2. LED light source sub-assemblies will be built to UL8750 for LED Lighting Equipment and to UL1598C for Luminaire standards.

3. The LED light fixture shall consume zero (0) watts in the off-state, excluding any control devices.

4. Installation instructions for all LED light source sub-assemblies to be provided by the manufacturer.

C. LED Light Source, Light fixture Manufacturers:

1. Seesmart Lighting.
2. Cooper – (Geier) Lighting.
3. Kenall Lighting.
4. Hubbell Lighting.
5. Cree Lighting.
6. L. C. Doane Company.
7. ESCO Lighting.
8. Acuity Brands (Lithonia Lighting).
9. Approved Equal.

D. LED Power Supply/Driver:

1. Power supply shall be Class 2 rated for a nominal input voltage of 120-277VAC with a voltage range of 90 – 305 VAC with an input frequency of 50/60 Hz, Current overshoot less than 20%, and Ripple current less than 15%.
2. The power supply shall be programmable, and shall have a constant light output feature.
3. Power supply shall be constant current type, and allow for 0-10vdc dimming
4. Power Supply shall be securely fixed to mounting plate so that it is not affected by vibrations.
5. Power supply shall carry NRTL labels.
6. Power supply shall be rated for operation and startup at temperatures ranging from -30 to 50 degrees C.
7. The Total Harmonic Distortion (THD) shall be less than 15%.
8. The power supply shall have a power factor greater than 90%.
9. The power supply shall have an audible noise rating of Class A or better.
10. Power supply line transient harmonics shall comply with EN 61003-2 and EMC immunity shall comply with IED 640004-4. Surge protection shall comply with combination wave test procedures per IED 610004-5 and ANSI C62.41.
11. The power supply shall be long-life (100,000 hours) and carry a ten (10) year warranty. Manufacturer shall be a full line power supply manufacturer with a five (5) year history of producing power supplies for the North American Market.

12. The power supply shall conform to FCC rules and regulations, as per Title 47 CFR Part 15 Non-Consumer (Class A).

13. Approved manufactures:

    a. Philips Advance
    b. Thomas Research Product

2.07. TYPE A FIXTURES

A. Recessed fixtures shall be of type suitable for suspended mounting below the type of ceiling as scheduled on the Fixture Schedule. Variations to catalog numbers indicated on the Fixture Schedule shall be made by the Contractor prior to placing order for the fixtures to insure proper mounting arrangement.

B. Fixtures shall be LED with drop lens diffusers that provide some up light.

C. Acceptable products are Lithonia lighting ZL1D, or approved equal including LED alternatives.

2.08. TYPE D EXTERIOR WALL PACKS

A. The wall packs for exterior use shall be LED light source with rugged and corrosion resistant construction, with a dark bronze finish.

B. Acceptable products are Lithonia lighting TWH LED, or approved.

2.09. TYPE F EMERGENCY LIGHTING FIXTURES

A. The fixtures for DC emergency lighting shall be twin PAR holder type. Acceptable products are Lithonia lighting OFTH 300PR, or approved equal.

B. The bulbs shall be LED. Acceptable products are GE LED 12 DBR 30/TP, or approved equal.

2.10. EXIT SIGN

A. General Requirements: Comply with UL 924, be Chicago Code Approved/Wet Location, and the following:

1. Provide as indicated on light fixture schedule included with contract drawings.

2. Sign Colors and Lettering Size to comply with authorities having jurisdiction.

3. Internally Lighted Sign: Light source for AC Operation to be White LED, 3.7 watts, 25 year life expectancy.

4. Standard input voltage shall be 120 Volts AC

5. Exit Sign shall be suitable for both interior and exterior locations.

6. Housing shall 20-Gauge stainless steel, white powder coat finish with vandal resistant lens.

7. Mounting shall be ceiling or back.

B. Exit Signs to be self-powered, battery type, with integral automatic charger in a self-contained power pack.

1. Battery to be sealed, maintenance-free, nickel-cadmium type, 6-volt operation, with special warranty.

2. Charger to be fully automatic, solid-state type with sealed transfer relay.

3. Operation to be as follows: Relay automatically energizes LED light source from unit when circuit voltage drops to 80 percent of nominal or below. When normal voltage is restored, relay disconnects lamps, and battery is automatically recharged and floated on charger.

C. Manufacturer of Exit Sign fixtures:

1. Big Beam Emergency Systems.

2. Approved equal.

2.11. LIGHT CONTROL

A. Provide local switching or occupancy sensors as indicated on the drawings.

2.12. ENVIRONMENTAL CONTROL

A. Gaskets:

1. Gasket shall be applied continuous at specified interfaces.

2. Gasket shall be applied around diffuser and its supporting frame and around diffuser door frame and fixture body.

3. Gasket material shall be closed cell neoprene, soft or medium density, even textured with high resistance to aging, heat, ultra-violet light, water, oils, weathering and setting.

4. Gaskets shall be cemented to the various components with resilient neoprene sealing compound. Compound shall be compatible with the finish to which it is applied.

5. Gasket shall not exhibit any noticeable stiffening at temperatures down to 0 degrees F and shall be satisfactory for long life in summer and winter temperatures in Chicago.

6. Water and aqueous solutions shall not cause swelling nor be absorbed by the gaskets.

B. Any drilling made on the fixture for conduit entry or mounting shall be sealed using manufacturer supplied gaskets and weather proof silicone sealers.

2.13. TESTS FOR FIXTURES

A. Fixtures shall be submitted in accordance with the requirements of the Special Conditions and Division 01. The Authority will determine if the submittal is in compliance with the requirements of this specification prior to the final acceptance of the fixture. Contractor shall submit one sample of each type of light fixture for approval of the Authority.

B. A minimum of 85% of the fixture lumens output shall fall within 60 degrees from nadir for type "B" and "E" fixtures and 90% of the fixtures lumens output shall fall within 120 degrees from nadir for type "C" fixture.

C. The main beam shall be at 90 degrees to the lens surface.

D. The following test reports shall be provided for each fixtures.

1. Photometric calculations (from 3 separate lighting manufacturers)

2. Vibration test data

3. LM-80

4. LM-79

5. TM-21 projection

2.14. MANUFACTURER

A. Manufacturer shall have 10 years experience fabricating fixtures for the outdoor environment.

B. LED fixture manufactures shall have 5 years experience fabricating fixtures using LED light source.

C. Fixture manufacturers shall provide references from three clients for similar applications.

2.15. FACTORY INSPECTION

A. Contractor shall require the manufacturer's production facility available to the Authority for inspection before and after manufacture of the fixtures called for under this contract.

PART 3 EXECUTION

3.01. INSTALLATION

A. The Contractor shall install the equipment in strict accordance with the approved shop drawings and the equipment manufacturer's recommendations.

B. Where aluminum contacts concrete or dissimilar metal, separate contact surfaces with gasket, non-absorptive tape or bituminous coating to prevent corrosion. Use stainless steel fasteners. Aluminum fixtures shall not be installed in contact with wood, or in any other situation where permanent moisture can exist.

C. Fixtures shall be mounted plumb, level and in straight lines. Group-mounted fluorescent/LED fixtures shall appear as one unit.

D. In areas where industrial type fixtures are to be installed such as Equipment Rooms, fixtures which are near obstructions near the ceiling such as ducts, large pipes, groups of pipes, etc., shall be suspended so that the bottom of the fixture is not higher than the bottom of the duct, etc. Outlets shall not be located until the location of these obstructions are determined. Outlets shall not be covered; conduits shall be installed exposed. Fixture shall have standard wire guard.

E. The Contractor shall supply all required lamps/LED lighting components, clean lamps, diffusers, globes, reflectors and exposed-to-view surfaces of fixtures after aiming and adjusting have been approved.

F. The Contractor shall provide gaskets and other means to make the fixture mounting and conduit entry watertight.

3.02. FIXTURE SUPPORTS

A. It shall be the Contractor's responsibility to provide and install all hardware to support all lighting fixtures adequately.

B. Each lighting fixture shall be rigidly supported from the building construction and shall include suspension hangers devices and extra steel work for fixture support where required.

C. The Contractor shall coordinate with the work of other trades to determine modifications required to make fixtures suitable for the location as installed, and verify the construction prior to fixture fabrication.

D. Recessed fixtures shall be provided with the proper plaster frame or suitable adapter to receive the finished ceiling construction.

E. Where suspended ceilings with steel channels occur, outlets and fixtures shall be supported on members resting on the channel framework. In no case shall fixtures be supported from plasterboard, plaster or acoustic material. No chains shall be used for hanging fixtures.

F. The Contractor shall not use the lighting fixtures as raceways. Any connections to adjacent fixtures or continuous rows of fixtures shall be through a separate raceway or system. Unistrut or other metal raceways are not acceptable for wiring connections.

G. Suspended fixtures shall be hung on ball and cushion swivel flexible fixture hangers, as manufactured by Appleton Electric Company or approved equal, and furnished by the Contractor and shall be adjusted as necessary during installation to insure that all fixtures in the same room or area are a uniform height detailed or noted on the Drawings.

3.03. MOTION SENSOR SWITCH INSTALLATION

A. Provide conduit, wiring and boxes for installation of motion sensor switches to control lighting in the space. Install according to manufacturer’s directions. A manual over ride option shall be provided for the motion control switch.

B. Program and adjust motion sensor switches for optimum operation at each space and Installation.

3.04. TESTING INSTALLATIONS

A. The Contractor shall furnish necessary personnel and equipment and perform tests and adjustments in the presence of the Authority’s Engineer. Testing of exterior installations shall occur during night hours when the lights are on.

B. The Contractor shall test lighting circuits for continuity and operation.

C. The Contractor shall test fixtures and mounting poles for continuity of grounding system.

D. The Contractor shall aim and adjust fixtures to provide distribution patterns approximately as shown and as approved.

3.05. FACTORY TESTING

A. The equipment must be completely assembled, wired, adjusted and tested at the factory. Rigid inspection before and after assembly must assure correctness of design and workmanship. After assembly, custom light fixtures must be tested for operation under simulated conditions.

B. A complete set of tests must be performed at the factory. The tests must include the manufacturer's standard and commercial tests, and specified tests, as specified, and a complete simulated operational test of the equipment to guarantee successful operation.

END OF SECTION

SECTION 26 95 00
ELECTRICAL TESTING

PART 1 GENERAL

1.01. RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02. SUMMARY

A. This section of Specification covers the tests and checks that shall be made on all electrical equipment and wiring to ensure compliance with the applicable codes and standards and with the Drawings and Specifications.

B. Related work specified elsewhere:

1. Section 26 03 00 Electrical Demolition.

2. Section 26 50 10 Lighting Fixtures

3. Section 34 21 27 Service and Distribution (600 V AC and Below)

4. Section 34 21 48 Substation Grounding

5. Section 34 21 61 General Provisions Traction Power

6. Section 34 21 65 Basic Electrical Materials and Methods – Traction Power

7. Section 34 21 90 Traction Power Substation Controls

1.03. SUBMITTALS

A. At a minimum, the following shall be submitted for review:

1. Field test procedure.

2. Test equipment specifications.

3. Field test results.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01. TEST REPORTS

A. The Contractor shall submit certified copies of test reports for all the tests conducted in field for Authority’s approval. Test reports shall be submitted to the Authority within seven days after completion of tests. Test reports shall contain the characteristic curves, etc. where required for interpretation of results.

3.02. CONDITIONS FOR TESTS

A. General Conditions

Prior to testing of any equipment specified in this Section, all of the following conditions shall be fulfilled by the Contractor:

1. All shop drawings of the equipment to be tested have been approved by the Authority.
2. The Contractor shall 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 shall arrange to conduct all tests per the Authority's approved procedure.
3. Testing shall 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, shall be submitted for review. 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. Contractor shall 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 shall 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 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.

3.03. TESTING

A. The following tests are required but shall not be limited to this list. Tests will be supervised and witnessed by the Authority.

1. Proper phase rotation
2. Short circuits
3. Improper grounds
4. Power and control electrical circuits for circuit continuity and function test
5. Megger insulation test
6. Hypot

B. Equipment / systems tested shall include, but not limited to:

1. 600 VAC or less switchboard controls and operation including testing and calibrating breakers
2. Facility grounding system, and ground relays
3. Lighting system and controls
4. Local alarms and remote monitoring through SCADA
5. Fire alarm system
6. Automatic transfer switches
7. HVAC system
8. Heat trace system
9. Lightning protection system

C. The Contractor shall furnish all meters, instruments, cable connections, equipment or apparatus necessary for making all tests.

D. The Contractor shall check and test all transformers, power panels, feeders, power and control cables, connections and motors to assure correct phase sequence and rotation. Phase sequence shall be A-B-C as follows:

1. Top to bottom, left to right and front to rear when facing protective or disconnecting mechanism.

2. Phasing shall be accomplished by using distinctive colors for various phases, as indicated in Section 34 21 65.

E. After wires and cables are in place and connected to devices and equipment, the system shall be tested for short circuits, improper grounds, and other faults. If fault condition is present, the trouble shall be rectified and the wiring system shall be retested.

F. Phase conductors, if shorted, grounded or at fault shall be removed, shall be replaced and the wiring system shall be retested.

G. A voltage test shall be made at each lighting panel, distribution panel and at the last outlet on each circuit. If drop in potential exceeds one percent, the Contractor shall correct the condition by locating the ground or high resistance splice or connection and retest.

H. Any wiring device, electrical apparatus, or lighting fixture grounded or shorted on any integral "live" part, shall be removed and the trouble rectified by replacing the defective parts or materials.

I. Upon completion of the electrical work, the Contractor shall place the entire installation in operation, test for proper function, and show systems and equipment to be free of defects. Motors and driven equipment shall not be run until properly lubricated. Pumps shall not be run until water or process fluid supply is connected and turned on. The Contractor shall test and record motor maximum load amperage and terminal voltage when uncoupled and coupled for each motor.

J. The Authority will conduct from time to time such tests as may be required to any part of the equipment to determine if it is installed in accordance with specifications. The Contractor shall extend to the Authority all facilities to this end and shall furnish skilled or unskilled help required.

K. The Contractor shall provide assistance to the various equipment manufacturers' field engineers as required in the testing and adjusting of the electrical power and control equipment. Cooperation of the Contractor shall be such that a minimum of time is required for equipment testing.

L. A log shall be maintained for all tests. This log shall be certified before completion of the job, both as to test value and date of test. All major equipment such as switchgear, and motors shall be energized initially in the presence of the Authority.

3.03. WIRE AND CABLE TESTING

A. All wires and cables No.6 AWG and larger shall be tested using megger after installation but before final connections are made. All 12 KV cables shall be either hypot tested at 38 KVDC for one minute, or VLF AC hypot tested at 20 KV for 30 minutes.

B. All tests shall be recorded on the form:

SINGLE & MULTIPLE CONDUCTOR POWER CABLE MEGGER TEST

WIRING - FEEDER CIRCUITS

Testing shall be performed before connecting the cable to the terminals at either end.
Each conductor shall be checked with a megger to ground, with all other conductors in the cable and shield, grounded. The minimum acceptable megger resistance for each conductor to ground shall be as per the NETA (National Electrical Testing Association) Table 100.1 for each conductor to ground.

Date
Project name ___________________________ feeder number _________ 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

If Applicable, All Shields Shall Be Properly Grounded prior to Testing.

Cable No.	MEGOHMS Phase A	MEGOHMS Phase B	MEGOHMS Phase C

TEST PERFORMED BY:____
Signature Date

TEST WITNESSED BY:____
Signature Date

NETA TABLE 100.1
Insulation Resistance Test Values Electrical Apparatus and Systems

Nominal Rating of Equipment in Volts	Minimum Test Voltage, DC	Recommended Minimum Insulation Resistance in Megohms
250	500	25
600	1,000	100
1,000	1,000	100
2,500	1,000	500
5,000	2,500	1,000
8,000	2,500	2,000
15,000	2,500	5,000

SECTION 28 31 10

FIRE DETECTION AND ALARM SYSTEM

PART 1 GENERAL

1.01. RELATED DOCUMENTS

A. Drawings and general provisions of contract, including General and Special Conditions and Division 01 Specification sections, apply to this section.

1.02. SUMMARY

A. These specifications provide for the furnishing, installation, and connection of the fire alarm equipment required to form a complete coordinated system ready for operation. The Fire Alarm System shall include, but not be limited to, alarm initiating devices, control panel, auxiliary control devices, annunciators, power supplies, and wiring as shown on the drawings and specified herein.

B. The fire alarm system shall comply with requirements of NFPA Standard No. 72 for protected premises signaling systems except as modified and supplemented by this specification. The system shall be electrically supervised and monitor the integrity of all conductors.

1.03. RELATED WORK SPECIFIED ELSEWHERE.

A. Section 34 21 65 Basic Electrical Materials and Methods

1.04. SCOPE

A. The work described in this Section consists of all labor, materials, equipment and services necessary and required to complete and test the Fire Alarm System. Any material not specifically mentioned in this Specification or not shown on the Drawings but required for proper performance and operation shall be furnished and installed.

B. Basic Performance requirements:

1. Addressable Signal Line (SLC) circuits shall be wired Class A (NFPA Style 6), supervised for opens and grounds.

2. Initiation device circuits shall be wired Class B (NFPA Style B), supervised for opens and grounds.

C. Basic System Functional Operation: When a fire alarm condition is detected and reported by one of the system initiating devices, the following functions shall immediately occur:

1. Initiate a general alarm in the building by activating the notification appliances.

2. Indicate the device in alarm at the main control panel, by activating an audible and visual alarm at the main control panel.

3. Indicate the zone in alarm at the main control panel, by activating an audible and visual alarm at the main control panel.

4. Provide two dry contacts signals, for both Alarm and trouble indications. Contacts for each of the two alarm conditions shall be for connection to a local annunciator, and for connection to the Communications System for transmitting to the Central Control Office. Provide necessary 48VDC rated auxiliary contacts for remote signal via SCADA system to remote CTA central office.

5. Provide one dry contact for interconnection with device 130 in the DC switchgear auxiliary cabinet. Provide the necessary 24VAC rated auxiliary contacts.

6. Provide one dry contact for interconnection with the temperature control panel for exhaust fan shutdown. Provide the necessary 24VAC rated auxiliary contacts.

1.05. SUBMITTALS

A. Shop Drawings: Include manufacturer's name(s), model numbers, ratings, power requirements, equipment layout, device arrangement, and complete wiring point-to-point diagrams.

B. Manuals: Submit simultaneously with the shop drawings, complete operating and maintenance manuals listing the manufacturer's name(s), including technical data sheets (with model numbers to be used indicated).

1.06. CODES AND STANDARDS

A. The publications listed below form a part of this specification.

1. National Fire Protection Association (NFPA) - USA:

a. No. 70-90 National Electrical Code (NEC).
b. No. 71-89 Central Station Signaling Systems.
c. No. 72-2007 Protective Signaling Systems, National Fire-Alarm Code

B. Underwriters Laboratories Inc. (UL) - USA:

1. No. 268 Smoke Detectors for Fire Protective Signaling Systems, July 20, 1987

2. No. 864 Control Units for Fire Protective Signaling Systems, May 26, 1987

3. No. 268 A Smoke Detectors for Duct Applications.
4. No. 521 Heat Detectors for Fire Protective Signaling Systems.

5. No. 464 Audible Signaling Appliances.

6. No. 1971 Visual Signaling Appliances.

7. No. 38 Manually Actuated Signaling Boxes.

8. No. 346 Waterflow Indicators for Fire Protective Signaling Systems.

C. City of Chicago Building Code

1. No. Article 620

2. No. Article 760

PART 2 PRODUCTS

2.01. EQUIPMENT AND MATERIAL, GENERAL

A. All equipment and components shall be new.

B. All equipment and components shall be installed in strict compliance with manufacturers' recommendations.

C. All Equipment shall be attached to and ceiling/floor assemblies and shall be held firmly in place. (e.g., detectors shall not be supported solely by suspended ceilings). Fasteners and supports shall be adequate to support the required load.

D. Equipment mounted in locations on grade, or electrically continuous with slabs on or below grade, shall be installed so as to maintain the electrical system isolation from earth ground.

2.02. CONDUIT AND WIRE

A. Conduit:

1. Conduit shall be in accordance with Section 16050 Raceways and Boxes of this Specification.

2. Conduit fill shall not exceed 40 percent of interior cross sectional area where three or more cables are contained within a single conduit.

3. Cable shall be separated from any open conductors of Power, or Class 1 circuits, and shall not be placed in any conduit, junction box or raceway containing these conductors, as per NEC Article 760-29.

4. Conduit shall be 3/4 inch minimum.

B. Wire:

1. All fire alarm system wiring shall be new and installed in conduit.

2. Number and size of conductors shall be as recommended by the fire alarm system manufacturer.

3. All field wiring to the indicating devices, shall be completely supervised.

C. Terminal Boxes, Junction Boxes and Cabinets:

1. All boxes and cabinets shall be UL listed for their use and purpose.

D. The Fire Alarm Control Panel (FACP) shall be connected to a separate dedicated branch circuit, maximum 20 amperes. This circuit shall be labeled at the Reliable Power

Distribution Panel as "FIRE ALARM". Fire Alarm Control Panel Primary Power wiring shall be 12 AWG.

2.03. SYSTEM COMPONENTS

A. Automatic Photoelectric / Heat Detectors:

1. Intelligent Multi Criteria Acclimating Detector: The intelligent multi-criteria detector shall be an addressable device that is designed to monitor a minimum of photoelectric and thermal technologies in a single sensing device. The design shall include the ability to adapt to its environment by utilizing a built-in microprocessor to determine its environment and choose the appropriate sensing settings. The detector design shall allow a wide sensitivity window, no less than 1 to 4% per foot obscuration. This detector shall utilize advanced electronics that react to slow smoldering fires and thermal properties all within a single sensing device.

2. The microprocessor design shall be capable of selecting the appropriate sensitivity levels based on the environment type it is in (office, manufacturing, kitchen etc.) and then have the ability to automatically change the setting as the environment changes (as walls are moved or as the occupancy changes).

3. The intelligent multi criteria detection device shall include the ability to combine the signal of the thermal sensor with the signal of the photoelectric signal in an effort to react hastily in the event of a fire situation. It shall also include the inherent ability to distinguish between a fire condition and a false alarm condition by examining the characteristics of the thermal and smoke sensing chambers and comparing them to a database of actual fire and deceptive phenomena.

B. Carbon Monoxide (CO) Detectors:

1. Compatible with the fire alarm system and shall be powered from by 24 Vdc nominal.
2. UL 2075 listed.
3. Alarm and trouble outputs.
4. Mounted to an electrical box with screw type wiring connections.
5. The LED indicator on the device shall indicate standby, alarm, and end-of-life.

C. Notification Appliances

General Requirements for Notification Appliances: Individually addressed, connected to a signaling-line circuit, equipped for mounting as indicated, and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.

2. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet (3 m) from the horn, using the coded signal prescribed in UL 464 test protocol.

3. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- (25-mm-) high letters on the lens.

   a. Rated Light Output: 15/30/75/110 cd, selectable in the field.

   b. Mounting: Wall mounted unless otherwise indicated.

   c. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.

   d. Flashing shall be in a temporal pattern, synchronized with other units.

   e. Strobe Leads: Factory connected to screw terminals.

   f. Mounting Faceplate: Factory finished, red.

2.04. MANUFACTURES:

A. Acceptable manufacturers of the fire alarm system shall be as manufactured by Notifier, Simplex, Siemens or approved equal.

PART 3 EXECUTION

3.01. INSTALLATION

A. Installation shall be in accordance with the NEC, NFPA 72, and local codes, as shown on the drawings, and as recommended by the major equipment manufacturer.

B. All conduit, junction boxes, conduit supports and hangers shall be concealed in finished areas and may be exposed in unfinished areas. Smoke/heat detectors shall not be installed prior to the system programming and test period. If construction is ongoing during this period, measures shall be taken to protect smoke/heat detectors from contamination and physical damage.

C. All fire detection and alarm system devices, control panels and remote annunciators shall be flush mounted when located in finished areas and may be surface mounted when located in unfinished areas.

D. At the final inspection a factory trained representative of the manufacturer of the major equipment shall perform the tests in Article 3.03 TESTS.

3.02. TEST

A. Provide the service of a competent, factory-trained engineer or technician authorized by the manufacturer of the fire alarm equipment to technically supervise and participate during all of the adjustments and tests for the system.

1. Before energizing the cables and wires, check for correct connections and test for short circuits, ground faults, continuity, and insulation.

2. Open initiating device circuits and verify that the trouble signal actuates.

3. Open and short indicating appliance circuits and verify that trouble signal actuates.

4. Ground circuits and verify response of trouble signals.

5. Check presence and audibility of tone at all alarm notification devices.

6. Check installation, supervision, and operation.

7. Verify that each initiating device alarm is properly received and processed by the FACP (Walk Test).

8. Conduct tests from the FACP to verify trouble indications for common mode failures, such as alternating current power failure.

3.03. FINAL INSPECTION

A. At the final inspection a factory trained representative of the manufacturer of the major equipment shall demonstrate that the systems function properly in every respect.

3.04. INSTRUCTION

A. Provide eight hours of instruction to the Commissioner's personnel. "Hands-on" demonstrations of the operation of all system components and the entire system shall be provided.

END OF SECTION

SECTION 31 20 00
EARTHWORK

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Special Conditions and Division 01 Specification sections, apply to this section.

1.02 SUMMARY

A. This Section includes but is not limited to the following work for the Broadway Substation Upgrades.:

1. Preparing and grading subgrades and providing subbase course for slabs on grade, walks, curb and gutter and pavements.
2. Excavating and backfilling for building foundations and footings, column foundations and footings, piers and other structures.
3. Excavating and backfilling for concrete for bollards, guard rails, fence posts, and other site work.
4. Soil and grading for planters, trees, shrubs and landscaping.
5. Removal and disposal of unsuitable soil or subgrade materials. Removal and stockpiling of material suitable for backfilling.
6. Providing, installing and compaction of fill and backfill materials.
7. Excavating and backfilling for underground sewer, water supply, catch basins, manholes, meter vault and electrical utilities and appurtenances.
8. Any other earthwork as shown on the drawings or required for installation of the new work.

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

1. Division 02 Section, Demolition.
2. Division 03 Section, Concrete.
3. Division 32 Section, Landscaping.

1.03 DEFINITIONS

A. Excavation consists of removal of material encountered to subgrade elevations indicated and subsequent disposal or stockpiling of materials removed.

B. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction of Authority. Unauthorized excavation, as well as remedial work directed by Authority, shall be at Contractor's expense.

1. 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 Authority. Unauthorized excavation may also be filled with compacted granular fill as approved by the Authority.

C. Unsuitable materials: Material which cannot be left in place for structural support of subsequent construction as determined by the Authority or material contaminated with fuel oil, lead or any other regulated substances.

D. Additional Excavation: When excavation has reached required subgrade elevations, notify Authority, who will make an inspection of conditions. If Authority 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 Authority.

E. Subgrade: The undisturbed earth or the compacted soil layer immediately below granular subbase, drainage fill, or topsoil materials.

F. Structure: Buildings, foundations, piers, footings, slabs, curbs, or other man-made stationary features occurring above or below ground surface.

1.04 SUBMITTALS

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

1. Verification of suitability and bearing capacity of each footing subgrade material, in accordance with specified requirements.
2. Field reports; in-place soil density tests.
3. Test reports of unsuitable and contaminated soil or subgrade materials.

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

C. Submittal by a licensed structural engineer of a drawing for the design of a temporary excavation shoring support system and including sealed calculations to the Authority for review and approval prior to beginning construction.

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 Illinois Department of Transportation Standard Specifications.

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

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 Authority.

D. Follow all applicable regulations, codes and ordinances when removing, transporting and disposing of contaminated subgrade materials.

1.06 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 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, consult utility owner immediately for directions. Cooperate with Authority and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of utility owner.
2. Do not interrupt existing utilities serving facilities occupied by Authority or others, except when permitted in writing by the Authority and then only after acceptable temporary utility services have been provided. Provide minimum of 48-hour notice to Authority, 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 jersey barricades as required and approved. Re-route traffic from traffic areas to be excavated.

E. The Contractor is responsible to hire a licensed structural engineer to design a temporary excavation shoring support system and submit sealed calculations and drawings to the Authority for review and approval prior to beginning construction.

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 Authority or material that is contaminated.

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

D. Subbase Material: To be used under structural slabs, and 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 Standard Specifications.

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 IDOT 1988. 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 Standard Specifications, Section 1004.

G. Porous granular backfill shall have a CA-18 gradation conforming to Section 704 of the Standard Specifications.

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

I. Trench Backfill: Trench backfill shall be a fine aggregate having a FA-6 gradation conforming to Article 1003.01 of the Standard Specifications.

J. 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.

K. 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.

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

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

N. Bearing soil or subbase for the installation of concrete foundation work shall be of 3000 psf bearing capacity minimum unless required or noted otherwise.

PART 3 EXECUTION

3.01 PREPARATION

A. Protect structures, 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.

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 his 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 Authority and at no additional cost to the Authority.

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

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 backfilling.

C. Shoring and Bracing: Provide materials for shoring and bracing, 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

A. Prevent surface water and subsurface or ground water from flowing into excavations and from flooding project site and surrounding area. Do not allow water to accumulate in excavations. Remove water to prevent softening of foundation bottoms, undercutting footings, and soil changes detrimental to stability of subgrades and foundations. Provide and maintain pumps, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations.

B. Contaminated water shall be disposed of properly by the Contractor and according to all applicable regulations. Submit procedures to the Authority for approval.

3.04 STORAGE OF EXCAVATED MATERIALS

A. Stockpile excavated materials acceptable, as designated by the Engineer, for backfill and fill. Place, grade, and shape stockpiles for proper drainage. Do not intermix materials. Cover to prevent wind-blown dust.

1. Locate stockpiled excavated materials in a location approved by the Authority.
2. Locate and retain soil materials away from edge of
3. excavations and out of the way of construction activities
4. Dispose of excess excavated soil material and materials not acceptable for use as backfill.

3.05 EXCAVATION

A. Excavate as required to extent required. Stockpile excavated material suitable for backfill. 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 properly off site.

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 foundations which are to remain shall be performed in such a way as to insure the stability of the existing foundations.

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 Authority's approval.

3.06 EXCAVATION FOR STRUCTURES

A. Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10 foot, and extending a sufficient distance from footings and foundations to permit placing and removal of concrete formwork, installation of services, and other construction and for inspection.

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

3.07 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.

3.08 APPROVAL OF SUBGRADE

A. Notify the Authority when excavations have reached required subgrade.

B. When the Authority determines that unforeseen unsatisfactory soil is present, continue excavation and replace with compacted fill material as directed.

C. Unsuitable soil may be soil of insufficient bearing strength or soil that is loose, mixed with debris. Bearing capacity to be determined by independent testing agent. Contractor to arrange for and pay for testing.

D. 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 Authority will be paid according to the contract provisions for changes in the work. Additional excavation must be approved in writing by the Authority.

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

3.09 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 Authority.

3.10 COLD WEATHER PROTECTION

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

3.11 UNSUITABLE EXCAVATION

A. All unsuitable excavated material and excess material not used for backfill or subgrade shall be disposed of at an approved off-site location. The Contractor shall provide written authorization to the Authority for the use of that location.

3.12 GRANULAR FILL AND BACKFILL

A. Granular fill or backfill shall be placed in accordance with Section 351 of the Standard Specifications.

B. Granular fill CA-6 shall be used for filling unauthorized, excessive or extended excavations from the bottom of the excavation to the bottom of the footing. Granular fill shall be installed and compacted in layers of maximum depth of 1'-0" per compacted layer.

C. A Lean Concrete Mix shall be used for fill greater than 1'-0" below the bottom of spread footing elevation.

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

E. 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 Authority for the material and compaction methods used. Moisture shall be added to the material during compaction only when it is necessary to increase the percentage of moisture to obtain satisfactory compaction and to prevent segregation.

F. 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 Authority and in such a manner which will not cause segregation and which will require minimum blading or manipulation.

G. Compaction tests shall be made at the direction of the Authority.

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

I. A minimum of 2 feet of granular backfill CA-6 compacted to 95% relative density.shall be provided as a subgrade under any new interior cast in place slab for the Broadway Substation.

J. Any non-organic approved backfill, granular backfill, or CA-6 shall be utilized in filling any abandoned vault or basement of the substations per the requirements listed above.

K. A minimum of 6” of granular backfill CA-6 compacted to 95% relative density shall be provided as a subgrade under any new cast in place footing, slab, or conduit bank either on grade or below grade.

L. Granular backfill CA-6 shall be used to backfill any excavated areas (as indicated on the drawings) around new footings, existing footing, or new conduit banks.

3.13 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 building slabs, walks and pavements, use compacted granular fill only.
3. Backfill trenches with concrete where trench excavations pass within 18 inches of column or wall footings and that are carried below bottom of such footings or that pass under wall footings. Place concrete to level of bottom of adjacent footing.

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 or 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.

3.14 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 installation of the foundation where applicable, but not prior to seven days after concrete placement or as approved by the Engineer.

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 Engineer 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 D 1557:

   a. Under structures, 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.

2. Moisture Control: Where subgrade must be moisture conditioned before compaction, uniformly apply water to surface of subgrade material. Apply water in minimum quantity as necessary to prevent free water from appearing on surface during or subsequent to compaction operations.

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

F. Granular backfill material is to have 6” maximum differential in lifts on all sides and uniformly compacted to 95% of the standard laboratory density at optimum moisture content and tested by an Illinois Geotechnical Engineer, according to IDOT Spec., Article 205.06.

G. Compaction: The CA6 material shall be placed in 4 inch to 8 inch horizontal lifts and uniformly compacted to 95% of the standard laboratory density at optimum moisture content and tested by an Illinois Licensed Geotechnical Engineer and submit the test results to the Authority for review.

3.15 GRADING

A. Grading Surface of Fill under Building Slabs: Grade smooth and even, free of voids, compacted as specified, and to required elevation. Provide final grades within a tolerance of 1/2 inch when tested with a 10-foot straightedge.

B. Compaction: After grading, compact subgrade surfaces to the depth and indicated percentage of maximum or relative density for each area classification.

3.16 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 2 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 a 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.

3.17 FIELD QUALITY CONTROL

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

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 D 1556 (sand cone method) or ASTM D 2167 (rubber balloon method), as applicable.

   a. Field density tests may also be performed by the nuclear method in accordance with ASTM D 2922, providing that calibration curves are periodically checked and adjusted to correlate to tests performed using ASTM D 1556. In conjunction with each density calibration check, check the calibration curves furnished with the moisture gages in accordance with ASTM D 3017.
   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 Authority.

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 a visual comparison of each subgrade with related tested strata when acceptable to Authority.
3. Paved Areas and Building Slab Subgrade: Perform at least one field density test of subgrade for every 2,000 sq. ft. of paved area or 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 Authority, 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.

3.18 DISPOSAL OF EXCESS AND WASTE MATERIALS

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

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

3.19 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 in approved land fills. All local, state, federal, OSHA, EPA, 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 Authority.

END OF SECTION

SECTION 31 20 10
EARTHWORK FOR UNDERGROUND UTILITIES

PART 1 GENERAL

1.01. RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General Conditions and Division 01 Specification sections, apply to this section.

1.02. SUMMARY

A. This Section includes but is not limited to the following:

1. Excavating and backfilling for underground utilities.

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

Division 33 Utilities, Section 33 68 00 Sewer Systems

2. Division 31 Earthwork, Section 31 23 00 Controlled Low Strength Material

3. Division 31 Earthwork, Section 31 20 00 Earthwork

1.03. DEFINITIONS

A. Excavation consists of removal of material encountered to elevations indicated and subsequent disposal or stockpiling of materials removed.

B. Subgrade: The undisturbed earth or the compacted soil layer immediately below granular bedding materials.

C. Unsuitable materials: Material which cannot be left in place or used as backfill as determined by the Authority or material contaminated with fuel oil, lead or any other regulated substances.

1.04. SUBMITTALS

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

1. Verification of suitability and bearing capacity of each footing subgrade material, in accordance with specified requirements.

2. Field reports; in-place soil density tests.

3. Test reports of unsuitable and contaminated soil or subgrade materials.

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

C. Submittal by a licensed structural engineer of a drawing for the design of a temporary excavation shoring support system and including sealed calculations to the Authority for review and approval prior to beginning construction.

1.05. QUALITY ASSURANCE

A. Codes and Standards: Perform excavation and backfilling work for utility trenches in compliance with the city of Chicago and applicable requirements of other authorities having jurisdiction.

B. Follow all applicable regulations, codes and ordinances when removing, transporting and disposing of contaminated excavated materials.

C. Contractor to obtain and pay for all required permits and pay for any cut-off fees or tap-in fees.

1.06. PROJECT CONDITIONS

A. Existing Utilities: Locate existing underground 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, consult utility owner immediately for directions. Cooperate with Authority and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of utility owner.

2. Do not interrupt existing utilities serving facilities occupied by Authority or others, during occupied hours, except when permitted in writing by the Authority and then only after acceptable temporary utility services have been provided. Provide minimum of 48-hour notice to Authority, and receive written notice to proceed before interrupting any utility.

3. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies for shutoff of services if lines are active.

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

C. 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 jersey barricades as required and approved. Re-route traffic from traffic areas to be excavated.

PART 2 PRODUCTS

2.01. TRENCH BEDDING MATERIALS

Bedding Course: Clean coarse aggregate, gradation CA-11 crushed stone conforming to Section 1004 of the IDOT Standard Specifications.

2.02. TRENCH BACKFILLING MATERIALS

A. Backfill for utility trenches: Clean Aggregate conforming to Section 208 of the IDOT Standard Specifications,

B. Backfill for Duct Bank trenches: Controlled Low Strength Material (C.L.S.M.) See Section 31 23 00 Controlled Low Strength Material

C. Earth Backfill for utility trenches in unpaved areas:

1. All backfill must be free of clay, roots, vegetative matter, chats, slag, debris, waste, rocks, concrete, bituminous pavement, masonry, frozen materials, or other objectionable hard or sharp material that could damage or puncture the utility line.

2. Backfill material shall not contain construction debris or corrosive materials.

3. Backfill materials 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.

PART 3 EXECUTION

3.01. PREPARATION

A. Protect existing utilities, sidewalks, pavements, landscaping, and other facilities from damage caused by settlement, lateral movement, undermining, washout, crushing, or other hazards created by earthwork.

B. Protect subgrades 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. Existing utility lines are to be flagged before beginning the work.

D. Contractor is responsible to determine the limits and elevations for his trenching operations; and if necessary have the work properly surveyed by a licensed surveyor and clearly marked.

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 Authority and at no additional cost to the Authority.

F. Existing pavements, 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. EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations.

1. Excavate trenches to allow installation of top of pipe below frost line.

B. Excavate trenches to uniform widths to provide the clearance on each side of pipe as indicated in plan detail drawings. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe, unless otherwise indicated.

1. Clearance:As shown on plans.

C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes. Shape trench bottom to provide continuous support for bells, joints, and barrels of pipes. Remove projecting stones and sharp objects along trench bottom.

1. Excavate trenches minimum four inches deeper than required elevation to allow for bedding course of CA-11 backfill. Hand excavate for bell of pipe.

D. Stockpile excavated material suitable for backfill. Remove all unsuitable materials and legally dispose of all materials not suited for backfill including unsuitable fill, debris, rubble, abandoned utility structures and pipe, pavements, curbs and gutters, fill and landscaping not to be reused. All unsuitable materials to be disposed of legally and properly off site.

E. All excavations shall be secured with temporary barriers.

3.03. 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 backfilling.

C. Shoring and Bracing: Provide materials for shoring and bracing as required to support excavation. Maintain shoring and bracing in excavations regardless of time period excavations will be open and until placement of backfill and assurance that removal of shoring will not deter the stability of adjacent structures.

3.04. COLD WEATHER PROTECTION

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

3.05. DE-WATERING

A. Prevent surface water and subsurface or ground water from flowing into excavations and from flooding project site and surrounding area. Do not allow water to accumulate in excavations. Remove water to prevent softening of trench bottoms and soil changes detrimental to stability of subgrades.

B. Contaminated water shall be disposed of properly by the Contractor and according to all applicable regulations. Submit procedures to the Authority for approval.

3.06. UTILITY TRENCH BEDDING

A. Place bedding material on subgrades free of mud, frost, snow, or ice. Place and compact bedding course on trench bottoms.

B. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes.

C. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of utility piping to avoid displacement of piping.

3.07. UTILITY TRENCH BACKFILL

A. After the pipe has been laid inside the trench and secured, and all pipe, fittings, joints, etc. have been inspected, backfilling should commence.

B. Place and compact initial backfill, filling depressions, of tamped sand backfill to a height of 12 inches over the full length of utility pipe.

C. Place fill materials in layers not more than 6 to 8 inches in loose depth. Compact using mechanical rammers or vibratory plates to 90 percent of maximum density (as determined by a laboratory using ASSTHRO method T180) or to utility specifications.

D. 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.

1. Where backfill must be moisture conditioned before compaction, uniformly apply water to surface of subgrade material. Apply water in minimum quantity as necessary to prevent free water from appearing on surface during or subsequent to compaction operations.

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

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

F. Percentage of Maximum Density Requirements: Compact soil to not less than the following percentages of maximum density, in accordance with ASTM D 1557:

1. Under structures, 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.

2. Under walkways, compact top 6 inches of subgrade and each layer of backfill or fill material at 95 percent maximum density.

3. Under lawn or unpaved areas, compact top 6 inches of subgrade and each layer of backfill or fill material at 90 percent maximum density.

G. For landscaped areas, top four inches of trench to be backfilled with clean black dirt, thoroughly tampered and compacted. Dirt to be mounded one inch maximum above adjacent grade, allowing for any settlement. For under paved areas, top portion of trench to be filled with compacted granular fill.

H. Backfill trenches excavated under footings and within 18 inches of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings.

I. Provide 4 inch thick concrete base slab support for piping less than 30 inches below surface of roadways. After installing and testing, completely encase piping in a minimum of 4 inches of concrete before backfilling or placing roadway subbase.

3.08. FIELD QUALITY CONTROL

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

B. If required, allow testing service to inspect and approve each fill layer before further backfill or construction work is performed.

1. Perform field density tests in accordance with ASTM D 1556 (sand cone method) or ASTM D 2167 (rubber balloon method), as applicable.

a. Field density tests may also be performed by the nuclear method in accordance with ASTM D 2922, providing that calibration curves are periodically checked and adjusted to correlate to tests performed using ASTM D 1556. In conjunction with each density calibration check, check the calibration curves furnished with the moisture gages in accordance with ASTM D 3017.

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 Authority.

2. If in opinion of Authority, based on testing service reports and inspection, fills that have been placed are below specified density, perform additional compaction and testing until specified density is obtained.

3.09. MAINTENANCE

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

B. Repair and reestablish 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.

D. Settling: Where settling is measurable or observable at excavated areas during general project warranty period, remove surface, add backfill material, compact, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.10. DISPOSAL OF EXCESS AND WASTE MATERIALS

A. Removal from Authority's Property: Remove waste and excess materials, including unacceptable excavated material, excessive material not used for backfill or subgrade, trash, and debris; and dispose of it legally and properly at an approved off-site location.

B. Material contaminated with fuel oil, lead or any other regulated substance must be excavated, removed and disposed of legally and properly as hazardous waste in approved land fills. All local, state, federal, OSHA, EPA, 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 other work; may be specified as such in the contract documents; may be discovered in the field; or may be otherwise identified by the Authority.

C. The Contractor shall furnish the Authority with information on the manner and location of disposal as well as evidence of their authority to use the location for either contaminated or non-contaminated waste.

END OF SECTION

SECTION 31 23 00
CONTROLLED LOW-STRENGTH MATERIAL

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and Division 01 Specification sections, apply to this section.

1.02 SUMMARY

A. This Section specifies ready-mix Controlled Low-Strength Material (C.L.S.M.) for the following applications:

1. Beddings, encasements and closures for tanks, manholes and pipes for the Broadway Substation.
2. Utility Trench backfill for new underground AC Cable Duct bank for the Broadway substation.

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

1. Section 31 20 00 – Earthwork.
2. Section 03 30 00 – Cast-In-Place Concrete.

1.03 DEFINITIONS

A. Ready-mix Controlled Low-Strength Material (C.L.S.M.) is used as an alternative to compacted soil and is also known as controlled density fill and flowable fill. Chemical admixtures may also be used in Controlled Low-Strength Material to modify performance properties of strength, flow, set and permeability. Pumpable mixes may be used.

B. Controlled Low-Strength Material shall be hand tool or machine tool excavatable at compressive strength of 150 psi (1.034 MPa) maximum at 1 year.

1.04 SUBMITTALS

A. Product Data: Submit manufacturer's Air-Entraining Admixture product data, installation instructions and recommendations for material use.

B. Test and Performance – Submit the following data:

1. Controlled Low-Strength Material shall have a maximum strength of 150 psi (1034 Mpa) according to ASTM C 39 at 180 days after placement.
2. Controlled Low-Strength Material shall have minimal subsidence and bleed water which is measured as a Final Bleeding of less than 2.0% (retains 98.0 percent of original height after placement, approximately ¼ " per foot of depth) as measured in Section 10 of ASTM C 940 "Standard Test Method for Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory".
3. Controlled Low-Strength Material shall have a unit weight of 90 – 110 lbs/ft^3 (1440 - 1760 kg/m3) measured at the point of placement after a 60 minute ready-mix truck ride.
4. Air-Entraining Admixture supplier shall have experience of at least one year.

1.05 QUALITY ASSURANCE

A. Manufacturer: Controlled Low-Strength Material shall be manufactured by a ready-mix concrete producer with a minimum of 1 year experience in the production of similar products.

B. Materials: For each type of material required for the work of this Section, provide primary materials which are the products of one manufacturer. If not otherwise specified here, materials shall comply with recommendations of ACI 229, "Controlled Low-Strength Materials".

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

D. 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 Authority.

1.06 DELIVERY, STORAGE AND HANDLING

A. Deliver and handle in strict compliance with manufacturer's recommendations. Protect from damage due to weather, excessive temperatures and construction operations.

1.07 PROJECT CONDITIONS

A. Perform work only when existing and forecasted weather conditions are within the limits established by the manufacturer of the materials and products used.

PART 2 PRODUCTS

2.01 MANUFACTURER

A. Provide Controlled Low-Strength Material manufactured by a ready-mix concrete producer experienced in the design and control of flowable mixtures. Manufacturer shall provide mixtures meeting performance properties specified herein.

B. Provide Air-Entraining Admixture for Controlled Low-Strength Material meeting specified requirements. Admixture may be in powder or liquid form and shall be able to meet the air content requirements of Mix 2.

2.02 MATERIALS

A. Portland Cement: ASTM C 150.

B. Provide Air-Entraining Admixture for Controlled Low-Strength Material meeting specified requirements. Admixture may be in powder or liquid form and shall be able to meet the air content requirements of Mix 2.

C. Aggregate: Provide material meeting the requirements of ASTM C 494.

D. Other Admixtures: Provide material meeting the requirements of ASTM C 494.

E. Pozzolanic Materials: Fly ash meeting ASTM C 618 requirements.

2.03 CONTROLLED LOW-STRENGTH MATERIAL MIXTURE

A. Mix design shall produce a consistency that will result in a flowable product at the time of placement which does not require manual means to move it into place.

B. Mix Design Criteria, Mixing and Proportioning. The mix design shall meet the following criteria.

Mix Design Criteria:

Flow	greater than or equal to 7 inches
Air Content	0-25%
Dynamic Cone Penetration (DCP) At 3 days	less than or equal to 1.5 inches/blow
Compressive Strength at 28 and 180 days	greater than or equal to 30 psi to less than 150 psi

C. The mix design shall be Mix 1, 2 or 3 and shall be proportioned to yield approximately one cubic yard.

Mix 1:

Portland Cement	50 lb
Fly Ash – Class C or F	125 lb
Fine Aggregate – Saturated Surface Dry	2900 lb
Water	50-65 gal
Air Content	No air is entrained

Mix 2:

Portland Cement	125 lb
Fine Aggregate – Saturated Surface Dry	2500 lb
Water	35-50 gal
Air Content	15-25%

Mix 3:

Portland Cement	40 lb
Fly Ash – Class C or F	125 lb
Fine Aggregate – Saturated Surface Dry	2500 lb
Water	35-50 gal
Air Content	15-25%

D. Contractor Mix Design. A Contractor may submit their own mix design and propose alternate fine aggregate materials, fine aggregate graduations or material proportions.

The mix design shall include the following information:

1. Source of materials.
2. Graduation of fine aggregate.
3. Specific gravities, material proportions and any other parameters used in the mix design process.
4. Type and proposed dosage of admixtures.
5. Target flow and air content.
6. Test data indicating compressive strength at 28 days and 180 days.

PART 3 EXECUTION

3.01 SAMPLING AND TESTING

A. The sampling and testing of CLSM shall be according to Illinois Test Procedure 307, “Sampling and Testing of Controlled Low-Strength Material (CLSM)”.

B. The dynamic cone penetration test (DCP) shall be according to Illinois Test Procedure 501, “Dynamic Cone Penetration (DCP)”.

3.02 PLACEMENT

A. The mix shall be placed directly from the chute into the space to be filled. Other placement methods may be approved by the Authority if the mix design is appropriate.

1. Structures. When backfilling against structures, the mix shall be placed in lifts as noted on the drawings to prevent damage by lateral pressures. Side slopes shall be stepped or serrated to prevent wedging action of the backfill against the structure. Each lift shall be allowed to harden prior to placing the next lift.

END OF SECTION

SECTION 31 23 23
UNCONTAMINATED BACKFILL, TOPSOIL, AND STRUCTURAL SOIL ACCEPTANCE

PART 1 APPLICABILITY

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Special Conditions and Division 01 Specification Sections, apply to this section.

B. By GSG Consultants, Inc.; dated May 6, 2016; titled “Phase I Environmental Site Assessment, CTA Broadway Street Substation.”

C. By GSG Consultants, Inc.; dated May 6, 2016; titled “Phase II Environmental Site Assessment, CTA Broadway Street Substation.”

1.02 GENERAL

A. This specification is for the historical review, collection and laboratory analysis of representative samples, and presentation of information for all off-site fill sources to be utilized for the project. All backfill materials being imported to the project site must comply with the environmental requirements in this specification.

1.03 DEFINITIONS

A. Agency means Illinois Environmental Protection Agency (IEPA).

B. Backfill means any granular or cohesive material used to fill an excavation or bring property to design grade as specified in the Architect/Engineer drawings and specifications.

C. CU Structural Soil means soils meeting Specifications, Section 704.

D. IEPA means Illinois Environmental Protection Agency

E. Owner: The entity who owns the land of which the project is built upon.

F. CTA Authorized Representative means the person designated as the official representative of the owner in connection with a project.

G. Top Soil means any soils placed to design grade and used to promote vegetative growth and which meets Top Soil criteria (percentages of organic matter, inorganic matter (silt, clay, and sand), deleterious material, pH, and mineral and plant-nutrient content as referenced in the contract specifications and drawings.

1.04 SUBMITTALS

A. Copies of environmental analytical results of all backfill material, top soil and CU Structural Soil verifying that these materials do not exceed APPENDIX B, SECTION 742, TABLE A; TIERED APPROACH TO CORRECTIVE ACTION OBJECTIVES (TACO): 35 ILL. ADM. CODE 742 values for 35 ILL. ADM CODE 740 APPENDIX A Target Compound List (TCL) parameters. For Target Compound Listed parameters know as PNAs, Appendix A Table H (Concentrations of Polynuclear Hydrocarbon Chemicals in background Soils) values may be used. For samples from virgin sources, one representative sample must be analyzed for 35 ILL. ADM CODE 740 APPENDIX A Target Compound List (TCL) parameters. For samples from recycled sources, one sample per 1,000 tons of material must be analyzed for 35 ILL. ADM CODE 740 APPENDIX A Target Compound List (TCL) parameters. A copy of the analytical results shall be submitted at least one week prior to depositing backfill or top soil on site. The date of the analysis shall be within 60 days of importing such material to the project.

B. A summary of the sample collection and data analysis. The report should include a tabulation of sampling results compared to applicable Tier 1 remediation objectives for residential properties.

C. Name and address and telephone number of the analytical testing laboratory that will be used by the Contractor to perform the environmental analytical testing for backfill, top soil and CU Structural Soil samples prior to starting work. The laboratory performing the analysis must be an IEPA accredited laboratory.

D. Name, Company, Address and Telephone number of the individual who performed the sampling and their specific sample handling methodology for each sample collected.

E. Source of all imported materials including but not limited to the address of the source site, the name of the owner of the source materials, the location where the source materials derived from at the source site, phone number of the owner of the source materials, history of the site usage (i.e. farm, residential, industrial/commercial, etc.)

F. Report defining the current and historic uses of the clean soil source material to determine if the potential for any source contamination is present.

G. Copies of all daily reports, transport records and receipts to the CTA Authorized Representative on a daily basis.

1.05 SUBMITTAL REVIEW

A. Review of submittals or any comments made does not relieve the Contractor from compliance with the requirements of the drawings and specifications. The purpose of this check is to review for general conformance with the design concept of the project and general compliance with the information given in the contract documents. The Contractor is responsible for confirming and correlating all quantities and dimensions; electing techniques of construction; coordinating the Work; and performing the Work in a safe and satisfactory manner.

B. The Contractor must not begin any Work applicable to this section until all required submittals have been reviewed and accepted by the CTA Authorized representative.

PART 2 - PRODUCTS

2.01 BACKFILL, TOP SOIL, CU STRUCTURAL SOIL

A. The contractor shall supply only backfill, top soil and CU Structural Soil that does not exceed APPENDIX B, SECTION 742, TABLE A; TIERED APPROACH TO CORRECTIVE ACTION OBJECTIVES (TACO): 35 ILL. ADM. CODE 742 values for 35 ILL. ADM CODE 740 APPENDIX A Target Compound List (TCL) parameters. For Target Compound Listed parameters known as PNAs Appendix A Table H (Concentrations of Polynuclear Hydrocarbon Chemicals in background Soils) values may be used. For samples from virgin sources, one representative sample must be analyzed for 35 ILL. ADM CODE 740 APPENDIX A Target Compound List (TCL) parameters. For samples from recycled sources, one sample per 1,000 tons of material must be analyzed for 35 ILL. ADM CODE 740 APPENDIX A Target Compound List (TCL) parameters. The date of the environmental analysis of any backfill, top soil or CU Structural Soil shall be within 60 days of importing such material to the project.

B. A summary of the sample collection and data analysis. The report should include a tabulation of sampling results compared to applicable Tier 1 remediation objectives for residential properties.

PART 3 - EXECUTION

3.01 AUTHORIZATIONS

A. Haulers for transportation of backfill, top soil or CU Structural Soil shall hold and present upon request a current, valid Commercial Driver's License (CDL).

B. Contractor shall have written approval from the CTA Authorized Representative prior to importing any backfill, top soil, or CU Structural Soil to the site.

3.02 MATERIAL SAMPLING

A. The Contractor shall collect sufficient amount of representative (no composite samples) backfill, top soil and CU Structural Soil sample(s) for analytical testing sufficient to verify that these materials do not exceed APPENDIX B, SECTION 742, TABLE A; TIERED APPROACH TO CORRECTIVE ACTION OBJECTIVES (TACO): 35 ILL. ADM. CODE 742 values for 35 ILL. ADM CODE 740 APPENDIX A Target Compound List (TCL) parameters. For Target Compound Listed parameters known as PNAs, Appendix A Table H (Concentrations of Polynuclear Hydrocarbon Chemicals in background Soils) values may be used. The Contractor is responsible for payment of all backfill, top soil and CU Structural Soil sampling and analytical fees.

B. The CTA Authorized Representative may collect backfill, top soil or CU Structural Soil samples for laboratory analysis on behalf of the CTA at no additional cost to the project.

C. The CTA Authorized Representative may need to collect samples for laboratory analysis or field Photo-ionization Detector (PID) screening, or liquid samples for laboratory analysis (as required by the CTA in special circumstances.) The Contractor shall provide the necessary equipment and manpower to assist the CTA Authorized Representative to collect materials to be sampled at no additional cost to the project and in compliance with OSHA and all other Rules and Regulations.

3.03 HAULING

A. The Contractor shall not create dust and shall maintain adequate dust suppression equipment on site if conditions warrant.

B. The Contractor shall maintain streets clean and free of mud and dirt.

C. The Contractor shall place backfill, top soil and CU Structural Soil to ensure minimum interference with roads; streets, walks and other adjacent occupied and used facilities. Do not close or obstruct streets, walks or other occupied or used facilities without permission from the applicable governing agency and the CTA Authorized Representative. Provide alternate routes around closed or obstructed traffic ways if required by the governing agency.

3.04 TRANSPORTATION

A. The Contractor shall provide and complete copies of all daily reports, weight tickets and receipts (as applicable) for transportation and ultimate placement of the backfill, top soil, and CU Structural Soil to the CTA Authorized Representative within five (5) business days or as directed by the CTA Authorized Representative.

B. The Contractor shall maintain all applicable or potentially affected streets from their operations clean and free of mud and dirt.

C. The Contractor shall schedule placement of backfill, top soil, and CU Structural Soil to ensure minimum interference with roads; streets, walks and other adjacent occupied and used facilities. Do not close or obstruct streets, walks or other occupied or used facilities without permission from the applicable governing agency and the Authority. Provide alternate routes around closed or obstructed traffic ways if required by the governing agency.

3.05 BACKFILL

A. The backfill material shall be granular or cohesive material that meets the project specified requirements.

B. For each off-site source of backfill materials, the Contractor shall provide to the CTA Authorized Representative, environmental laboratory analyses and certification that the imported backfill does not exceed APPENDIX B, SECTION 742, TABLE A; TIERED APPROACH TO CORRECTIVE ACTION OBJECTIVES (TACO): 35 ILL. ADM. CODE 742 values for 35 ILL. ADM CODE 740 APPENDIX A Target Compound List (TCL) parameters. For Target Compound Listed PNAs known as PNAs, Appendix A Table H (Concentrations of Polynuclear Hydrocarbon Chemicals in background Soils) values may be used. For samples from virgin sources, one representative sample must be analyzed for Appendix B, Section 742 Table A parameters. For samples from recycled sources, one sample per 1,000 tons of material must be analyzed for Appendix B, Section 742

Table A parameters. The date of the analysis of any backfill shall be within sixty (60) days of importing such material to the project.

C. The contractor shall not place backfill material without approval of the CTA Authorized Representative. If the Contractor backfills the excavation area without obtaining approval from the CTA Authorized Representative, the backfill materials shall be excavated, if required, at the Contractor's expense.

3.06 TOP SOIL

A. The Top Soil material shall meet the project structural specifications.

B. For each off-site source of top soil, the Contractor shall provide to the CTA Authorized Representative as required, environmental laboratory analyses and certification that the imported top soil does not exceed APPENDIX B, SECTION 742, TABLE A; TIERED APPROACH TO CORRECTIVE ACTION OBJECTIVES (TACO): 35 ILL. ADM. CODE 742 values for 35 ILL. ADM CODE 740 APPENDIX A Target Compound List (TCL) parameters. For Target Compound Listed PNAs known as PNAs, Appendix A Table H (Concentrations of Polynuclear Hydrocarbon Chemicals in background Soils) values may be used. For samples from virgin sources, one representative sample must be analyzed for 35 ILL. ADM CODE 740 APPENDIX A Target Compound List (TCL) parameters. For samples from recycled sources, one sample per 1,000 tons of material must be analyzed for 35 ILL. ADM CODE 740 APPENDIX A Target Compound List (TCL) parameters. The date of the analysis of any backfill top soil shall be within sixty (60) days of importing such material to the project.

C. The contractor shall not place top soil without approval of the CTA Authorized Representative. If the Contractor places top soil without obtaining approval from the CTA Authorized Representative, the top soil shall be excavated, if required, at the Contractor's expense.

3.07 DUST CONTROL

A. The Contractor shall control dust by all necessary means, including but not limited to covering trucks, stockpiles and open materials, watering haul roads, sweeping paved roads, and limiting the speed of all on-site vehicles.

B. The Contractor shall prevent vehicles from tracking mud off site. Contractor shall perform all necessary activities to keep roadways clean throughout each day and for the duration of the project.

END OF SECTION

SECTION 31 63 33
MICROPILES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and General Provisions of the Contract, including General and Special Conditions and Division 01 Specification Sections, apply to this section.

1.02 SUMMARY

A. Contractor shall be responsible for selecting the micropile type, installation method, grout pressures, and any necessary changes to the structural elements, such that the micropiles will carry both the compressive and tension design loads indicated on the plans at the maximum tolerable deflections specified. The Contractor shall demonstrate the micropile adequacy by performing pile load test(s) and micropile proof tests that satisfy the acceptance criteria of this Specification.

B. This Section includes the designing, furnishing, installing and testing the proposed micropiles according to the plans, approved shop drawings, and this Specification.

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

1. Section 03 20 00 - Concrete Reinforcement
2. Section 03 30 00 - Cast-in-Place Concrete
3. Section 31 20 00 - Earthwork
4. Section 31 20 10 - Earthwork for Underground Utilities

1.03 SUBMITTALS

A. The Contractor selected to perform this work shall satisfy the qualification requirements and shall provide shop drawings for the proposed micropile installation.

B. Qualifications:

1. The Contractor performing the work shall have personnel experienced in the design, construction and testing of micropiles. The Contractor shall have successfully installed a total of at least 100 micropiles on no less than five (5) different projects completed within the last five (5) years of similar project conditions and capacities to those required on this project.

1. The Contractor shall assign a field supervisor with experience on at least three (3) projects of similar scope to this project, completed over the past five (5) years. The on-site foreman and drill rig operator(s) must have completed three (3) projects within the last five (5) years involving micropiles of equal or greater capacity than required on this project. The Agency may suspend the micropile work if the Contractor substitutes unqualified personnel and the Contractor shall be liable for additional costs resulting from the suspension.

2. The above experience qualifications list and personnel list shall be submitted for approval prior to or with the shop drawings submittal.

C. Design Calculations and Shop Drawings.

1. At least five weeks before work is to begin, the Contractor shall submit to the Agency for review and approval, design calculations and complete shop drawings describing the micropile system, or systems, intended for use. The micropiles shall be designed and detailed to carry the tension and compression loadings indicated on the plans. The submittal shall be prepared and sealed by an Illinois Licensed Structural Engineer and include (as a minimum) the following:

2. Design calculations including the following:

    a. Applicable code requirements and design reference literature used in the geotechnical and structural computations.

    b. Micropile design profile cross-section(s) geometry including casing plunge length(s), bonded lengths and minimum diameter, the soil/rock strata anticipated, and the piezometric levels.

    c. Design criteria including soil/rock shear strengths (friction angle and cohesion), unit weights, minimum grout compressive strength, ground/grout bond values, and assumptions for each soil/rock strata.

    d. Resistance factors used and the resulting factored geotechnical resistance of each portion of the micropile.

    e. Structural design calculations sizing the load and proof testing frame, reaction piles and connections to both the reaction piles and micropiles. Geotechnical calculations shall be submitted to indicate that a minimum factored resistance exists for the reaction piling equal to twice the maximum test loading.

    f. If proposing to modify the anchorage head assembly, connection to footing, casing, reinforcement, bond lengths, grout strength, bearing plate or weld details shown in the plans, structural calculations supporting these changes shall also be submitted.

3. Shop drawings including the following:

    a. Plan view of the showing:
        i. All proposed micropiles with each labeled with a unique identification number.
        ii. Locations of subsurface exploration borings plotted and labeled.
        iii. Proposed overall sequence of construction.
        iv. Locations of micropiles to be proof tested and load tested.

    b. Elevation view of the project showing:
        i. The location of the existing substructures and all soil boring data plotted with all major changes in soil type or stratification identified.
        ii. The proposed micropile lengths plotted at each substructure as well as the bottom of casing, top of bonded length, plunge length and minimum tip elevations indicated.
        iii. All general notes for constructing the micropiles.

    c. Micropile typical section showing:
        i. The proposed typical micropile configuration(s) including steel casing, reinforcement sizes, grout tubes and minimum grouted diameters (in both the cased and bonded lengths).

ii. Step by step installation procedure(s) including casing advancement, grouting elevations, re-grouting, etc.
iii. Reinforcement centralizers and spacer locations and details.
iv. Casing splice details.

d. Anchorage head assembly details including reinforcement, casing, bearing plate, embedment/connection to footing and required weld sizes if proposing to deviate from those provided in the plans.
e. Any revision to details shown on the plans necessary to accommodate the micropile system intended for use.

f. Micropile load and proof testing sheet showing:
i. Load frame and anchor pile details for load tests.
ii. Load frame and reaction pile connection for proof testing production piles.
iii. Any additional reinforcement and grout strength required in the load test micropiles to permit testing to 1.5 times the design loadings.
iv. Jack, pressure gauge and load cell calibration curves.

g. The grout mix design and procedures for monitoring and recording the grout depth, volume and pressure during the grouting process.

D. Work shall not start on any micropile, nor shall materials be ordered, until the shop drawings and qualifications have been approved in writing by the Engineer.

PART 2 PRODUCTS

2.01 MATERIALS

A. The materials used for the construction of the micropiles shall satisfy the following requirements.

B. Reinforcement Steel: Micropiles reinforcement shall consist of single or multiple elements of either 150 ksi (1034 MPa) or 75ksi (520 MPa) (f_u) high strength threadbars or deformed bars conforming to ASTM A722 or A706.

C. Steel Couplers: Prestressing steel couplers shall be capable of developing 95 percent of the minimum specified ultimate tensile strength of the reinforcement steel.

D. Grout: The grout shall consist of a neat cement or sand cement mixture of Type II, III or V portland cement conforming to Section 1024.01 of the Standard Specifications. The minimum compressive strength of the grout shall be as specified on the plans but not less than 4 ksi (27.6 MPa). Expansive admixtures may not be used except to seal the encapsulations and anchorage covers. Admixtures to control bleed, improve flowability, reduce water content, and retard set may be used if approved by the Engineer. Accelerators and admixtures containing chlorides are not permitted.

E. Fine Aggregate: If sand-cement grout is used, sand shall conform to the requirements for fine aggregates according to Section 1003 of the Standard Specifications.

F. Spacers: Spacers for separation of elements of a multi-element reinforcement shall permit the free flow of grout. They shall be fabricated from plastic, steel or material which is not detrimental to the reinforcement. Wood shall not be used. Spacers shall be placed along the total length of the micropile so that the steel will bond to the grout. They shall be located at 10 ft (3 m) maximum centers with the upper one located a maximum of 5 ft (1.5 m) from the top of the micropile and the lower one located a maximum of 5 ft (1.5 m) from the bottom of the bonded length.

G. Centralizer: Centralizers shall be fabricated from plastic, steel or material which is not detrimental to the reinforcing steel. Wood shall not be used. Centralizers shall be able to maintain the reinforcement position and alignment so that a minimum of 1.5 inches (38 mm) of grout cover is obtained at all locations below the cased micropile length. They shall be located at 10 ft (3 m) maximum centers with the lower one located one foot from the bottom of the bonded length.

H. Anchorage head assembly: The materials properties, dimensions, and design details for the micropile anchorage head assembly components shall be as specified on the contact plans unless otherwise proposed by the Contractor and approved as part of the shop drawings submittal. Anchorage components may include bearing plates (ASTM A572 Grade 50), shear studs, reinforcement steel, nuts, casing and other approved components.

I. Steel casing: Steel casing shall be ASTM A53 Gr. B of the wall thickness and diameter shown on the plans. Any changes to this casing shall be submitted to the Agency for review and approval as part of the shop drawing submittal.

PART 3 EXECUTION

3.01 CONSTRUCTION REQUIREMENTS

A. The drilling method used may be rotary drilling, percussion drilling or an approved alternate. The method of installation used shall be that which prevents loss of ground around the drilled hole that may be detrimental to the structure. The drillhole shall be maintained open along its full length at the minimum drillhole diameter specified on the approved shop drawings prior to placing reinforcement and grout. Temporary casing or other approved method of micropile drillhole support shall be required in caving or unstable conditions.

B. The Contractor shall notify the Engineer if an obstruction is encountered. An obstruction is an unknown isolated object that causes the excavation to experience a significant decrease in the actual production rate and requires the Contractor to core, break up, push aside, or use other means to mitigate the obstruction. Subsurface conditions such as boulders, cobbles, or logs and buried infrastructure such as footings, piling, or abandoned utilities, when shown on the plans, shall not constitute an obstruction. When an obstruction is encountered, the Contractor shall notify the Engineer immediately and upon concurrence of the Engineer, the Contractor shall mitigate the obstruction with an approved method unless relocating the micropile would be less expensive.

C. Casing shall be installed in sections of appropriate lengths with threaded connections. The casing shall be capable of advancing the hole through the soil strata as indicated in the boring data. Welded Joints may be used if the welding detail is submitted and approved as part of the shop drawings.

D. The reinforcement shall be placed prior to grouting. The reinforcement shall be inserted to the desired depth without undue stress or difficulty (not driven or forced). When the reinforcement cannot be completely inserted it shall be removed and the drill hole cleaned or re-drilled to permit insertion. The reinforcement shall be free of soil, grease, or oil that might reduce the grout to bar bond.

E. The micropiles shall be grouted within 24 hours after the load transfer bond length is drilled.

Grout shall be free of any lumps and undispersed cement. The grout volumes and pressures shall be measured and recorded during the placement operation. The pump shall be equipped with a grout pressure gauge at the pump and a second gauge placed at the point of injection at the top of the casing to monitor grout pressures. The gauges shall be capable of measuring pressures of at least 150 psi (1.0 MPa) or twice the actual grout pressures used, whichever is greater. The grout shall be continuously agitated after mixing. All grout shall be place within one hour of mixing. The grouting equipment shall be sized to enable each pile to be grouted in one continuous operation. The grout shall be injected from the lowest point of the drillhole (through grout tubes, casing, drill rods, etc.) and continued until uncontaminated grout flows from the top of the micropile. Temporary casing, if used, shall be extracted in stages ensuring that, after each length of casing is removed, the grout level is brought up to ground level before the next length is removed. The casing or grout tube shall always extend below the level of the grout in the drillhole. Upon completion of grouting, the grout tube or access valve may remain in the drill hole and anchorage head assembly provided it is filled with grout. The grout take and pressure shall be controlled to prevent any heave of the ground surface or foundations.

F. The Contractor shall monitor the existing foundation for movement. If movement is detected, the Contractor shall immediately stop production and notify the Engineer. Work shall not resume until the Contractor’s recommendations to remedy the situation are approved by the Engineer.

The following construction tolerances shall apply to all production micropiles:

1. The center of the micropile casing shall be within 2 in. (50 mm) of plan location in any direction at the top of the pile.

2. The deviation of the shaft batter from that specified shall not exceed 1/8 in./ft. (10 mm/m).

3. The top of the casing shall be within ± 2 inches (50 mm) of the plan elevation.

G. Micropile Load Test and Micropile Proof Test.

1. The Contractor shall load test a production micropile(s) as well as proof test selected production micropiles. The load testing shall be performed by incrementally loading the micropiles according to ASTM D 1143 for the compression loading and ASTM D 3689 for the tension loading using the Quick Load Test Method except as modified herein. Testing shall not take place until the grout has acquired the specified design strength.

2. The jack ram travel shall be positioned at the beginning of the test so that unloading and repositioning during the test shall not be required. When both compression and tension loading is to be performed, it shall be performed on the same micropile and the compression loading shall be conducted first. Dial gauges capable of measuring displacements to 0.001 inch (0.025 mm) shall be used to measure micropile movement of the jack from an independent reference point. If the test setup requires reaction against the ground or a single row of reaction piles, two gauges shall be used on either side of the micropile. The reaction frame and piles shall be adequately stiff to prevent excessive deformation, misalignment or racking under peak loading. The stressing equipment shall be placed over the micropile in such a manner that the jack, load cell, and load test reaction frame are axially aligned with the anchorage head assembly reinforcement. Gauges shall have adequate travel so the total micropile movements can be measured without resetting the devices.

3. Test loads shall be applied with a hydraulic jack and measured with a pressure gauge.

The pressure gauge shall be graduated in 72 psi (500 kPa) increments or less. The jack and pressure gauge shall have a pressure range not exceeding twice the anticipated maximum test pressure. Monitor the creep test load hold during testing with both the pressure gauge and electronic load cell. The load cell shall be used to accurately maintain a constant load hold during the creep test load hold increment of the testing.

H. Micropile Load Test.

1. The Contractor shall perform a production micropile load test(s) to verify the design and the construction methods proposed prior to completing the installation of production micropiles. The number and general location of the load test(s) are indicated in the plans and shall be constructed and tested according to this specification and the approved shop drawings

2. The micropile load test Design Load shall be taken as the maximum factored compression and tension strength group loadings indicated at any substructure covered by the load test as shown on the plans. Micropiles not founded in rock shall follow the test loading schedule shown below. Micropiles founded in rock may omit increments 1 through 12:

<u>Load Test Schedule</u>

Increment	Loading Applied	Increment	Loading Applied
1	Alignment Load	13	Alignment Load
2	0.25 Design Load	14	0.25 Design Load
3	0.50 Design Load	15	0.50 Design Load
4	Alignment Load	16	0.75 Design Load
5	0.25 Design Load	17	1.00 Design Load
6	0.50 Design Load	18	1.25 Design Load
7	0.75 Design Load	19	1.50 Design Load
8	Alignment Load	20	1.00 Design Load
9	0.25 Design Load	21	0.50 Design Load
10	0.50 Design Load	22	0.25 Design Load
11	0.75 Design Load	23	Alignment Load
12	1.00 Design Load		

3. The dial gauges shall be reset to zero after the initial Alignment Load increment is applied. The Alignment Load is defined as the minimum load necessary to maintain alignment of the stressing equipment and reaction frame. The load holding period shall start as soon as each load increment is fully applied and last for 1 minute for each increment with the exception of the 1.0 load increments which shall be held for 10 minutes. The jack shall be re-pumped as necessary in order to maintain a constant load during this period. The micropile deflections shall be measured and recorded at the end of the load holding period. In addition, the 1.0 load hold increment shall be monitored for creep by recording the micropile movements at 1, 2, 3, 5, 6, and 10 minutes during the load hold. If the movement between the 1 and 10 minute increments exceeds 0.04 inches (1 mm), the load hold shall be extended and held for an additional 50 minutes. Movement shall be recorded at the 15, 20, 30, 40, 50 and 60 minute time increments.

4. A graph shall be constructed showing a plot of anchorage head assembly movement deflections versus test loading (both tension and compression) at the end of each load

increment in the test schedule including the rebound measurements after unloading.

5. The acceptance criteria, demonstrates a successful load test, are as follows:

   a. The micropile shall carry at least 1.0 times the design compression and tension loadings with a deflection of the anchorage head assembly less than the theoretical elastic deflection from its anchorage head to the midpoint of the bonded length.

   b. The micropile shall have a creep rate not exceeding 0.08 inch (2 mm)/log cycle of time at the end of the 1.5 times the Design Load increment. The creep rate graphed on log scale shall be linear or decreasing throughout the creep load hold period.

   c. The nominal geotechnical resistance shall exceed 1.5 times the factored compression and tension design loads shown on the plans, as determined using Davisson Method as presented in AASHTO article 10.7.3.8.2.

6. In the event that a load tested micropile fails the acceptance criteria, the Contractor shall re-evaluate his/her design and construction procedures, making the necessary changes to install an additional production micropile and any additional anchor pile(s) to allow another load test. The above process shall be repeated until a successful micropile passes the load test acceptance criteria. Payment for the successful load test shall include all work associated with any failed micropile load test(s).

7. The Engineer will provide the Contractor with written confirmation of the micropile design and construction within 10 working days of the completion of the load test(s). This written confirmation shall confirm the adequacy of the bonded lengths and tip elevations shown on the Contractor's shop drawing or the revised values required due to any failed micropile.

8. Load tested micropiles and reaction piles located in non-production locations shall be cut 2 ft. (600 mm) below finished grade after completion.

I. Micropile Proof Test

1. The Contractor shall install a set of micropiles at each substructure unit designated to have micropiles for the purpose of conducting a proof test on a production micropile. A set of micropiles is defined as the minimum number of micropiles (production or sacrificial) required to proof test a production micropile and provide the proof test load frame reaction capacity. If the contactor chooses to install additional production micropiles prior to proof testing, re-grouting or additional micropiles may be required at the contractor expense should the proof test not pass the acceptance criteria.

2. The proof test Design Load shall be taken as the maximum factored compression and maximum tension strength group loadings indicated at each substructure, shown on the plans. The loadings shall be incrementally applied according to the schedule shown below:

Proof Test Schedule

Increment	Loading Applied	Increment	Loading Applied
1	Alignment Load	7	0.90 Design Load

2	0.15 Design Load	8	1.00 Design Load
3	0.30 Design Load	9	0.75Design Load
4	0.45 Design Load	10	0.50 Design Load
5	0.60 Design Load	11	0.25 Design Load
6	0.75 Design Load	12	Alignment Load

3. The dial gauges shall be reset to zero after the initial Alignment Load increment is applied. The Alignment Load is defined as the minimum load necessary to maintain alignment of the stressing equipment and reaction frame. The load holding period shall start as soon as each load increment is fully applied and last for 1 minute for each increment with the exception of the 1.00 load increment which shall have a 10 minute load hold. If the top of the micropile movement between the 1 minute and 10 minute time intervals exceeds 0.04 inches (1 mm), the 1.00 load hold shall be maintained for an additional 50 minutes. The jack shall be re-pumped as necessary in order to maintain a constant load during this period. The micropile deflections shall be measured and recorded at the end of the load holding period. The 1.00 load hold increment shall be monitored by recording the micropile movements at 1, 2, 3, 5, 6, and 10 minutes and if extended shall be recorded at the 20, 30, 50, and 60 minutes during the load hold.

3. A graph shall be constructed showing a plot of anchorage head assembly movement deflections versus test loading (both tension and compression) at the end of each load increment in the test schedule including the rebound measurements after unloading.

4. The acceptance criteria, demonstrating a successful load test, are as follows:

   a. The micropile shall carry at least 1.0 times the design compression and tension loadings with a deflection of the anchorage head assembly less than the theoretical elastic deflection from its anchorage head to the midpoint of the bonded length.

   b. The micropile shall have a creep rate not exceeding 0.08 inch (2 mm)/log cycle of time at the end of the 1.0 times the Design Load increment. The creep rate graphed on log scale shall be linear or decreasing throughout the creep load hold period.

6. In the event that a production micropile fails the proof test acceptance criteria, the Contractor shall re-evaluate his/her design and construction procedures, make the necessary changes and install additional anchor pile(s), outside the proposed footing and proof test the revised micropile. The above process shall be repeated until a micropile passes the acceptance criteria. The set of production micropiles installed as part of the failed proof test shall be cut flush with the bottom of the footing and supplemented by micropiles installed using improved design and installation methods adjacent to the failed micropiles. The failed load test(s), any supplemental or additional anchor piles, or micropiles cut flush with the bottom of the footing shall be included with the successful micropile proof test loading.

END OF SECTION

SECTION 32 10 00
STABILIZED AGGREGATE SURFACE

PART 1 - GENERAL

1.01. RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Special Conditions and Division 01 Specification sections, apply to this section.

1.02. WORK INCLUDED

A. This work shall consist of furnishing and placing one or more courses of aggregate upon a prepared subgrade.

B. Reference Specifications: Work under this item shall be performed in accordance with the IDOT Standard Specifications Section 402.

1.03. RELATED WORK

A. Section 31 20 00 - Earthwork

PART 2 - PRODUCTS

2.01. MATERIALS

A. Materials shall be as shown on the drawings and meet the requirements of Section 1004.04 of the Standard Specifications.

PART 3 - EXECUTION

3.01. GENERAL

A. The subgrade shall be prepared according to applicable articles of Section 301 of the IDOT Standard Specifications.

B. Aggregate Surface Course shall be placed and compacted in accordance with Section 402 of the IDOT Standard Specifications.

END OF SECTION

SECTION 32 12 00
HOT MIX ASPHALT PAVEMENTS

PART 1 GENERAL

1.01. RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Special Conditions and Division 01 Specification Sections, apply to this section.

1.02. SUMMARY

A. The work under this Section shall include furnishing all labor, materials, tools and equipment required to furnish and place Hot Mix Asphalt (HMA) surface course over granular material subbase course; to resurface, replace or patch existing.

B. Work also includes installation of seal coat over new surfaces and replacing any pavement markings.

C. Pavement as shown on the drawings; minimum thicknesses as specified in the Standard Specifications, SSRBC, CDOT Rules and Regulations for Construction in the Public Way, unless shown otherwise on the drawings, as contained in this Specification and transitions to match or align with existing pavements.

D. Pavement shall consist of HMA, and aggregate subbase as required.

1.03. REFERENCES

A. Standard Specifications: Refers to Illinois Department of Transportation (IDOT) , Standard Specifications for Road and Bridge Construction (SSRBC), adopted April 1, 2016, (IDOT), IDOT Supplemental Specifications and Recurring Special provisions adopted January 1, 2017..

1. Division 300, Subgrades, Subbases and Base Course and

2. Division 400, Surface Courses, Pavements, Rehabilitation and Shoulders and

B. Federal Highway Administration (FHWA) Manual of Uniform Traffic Control Devices, latest edition.

C. Chicago Department of Transportation (CDOT): Rules and Regulations for Construction in the Public Way, March 2016 or latest edition.

1.04. RELATED WORK

A. Related work specified elsewhere includes:

1. Section 31 20 00, Earthwork.

2. Section31 20 10 Earthwork for Underground Utilities
3. Section 31 23 00, Controlled Low Strength Material

1.05. SUBMITTALS

A. The Contractor shall submit product data, manufacturer's test reports, specifications, installation recommendations, and certificates for binder course, surface course, bituminous materials and mixture, and seal coat.

PART 2 PRODUCTS

2.01. MATERIALS

A. General: Provide materials in accordance with requirements of the IDOT Standard Specifications (SSRBC) Sections 351, 353, 406 and 1000 series as specified hereinafter.

B. Aggregate Base Course: IDOT Standard Specifications, (SSRBC) Section 351, Type B except only gradation CA-6 aggregate is allowed.

C. Prime and Tack Coats: IDOT Standard Specifications, (SSRBC) Article 406.02 and Section 1032.

REQUIRED MIX: HMA SURFACE COURSE, MIX D, N50, 4% AIR VOIDS AT 60 GYR.PER STANDARD SPECIFICATIONS, SSRBC SECTION 1030.PART 3 EXECUTION

3.01. EXAMINATION

A. Examine the areas to receive the Work and the conditions under which the work will 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.

B. Coordinate all work with the CTA and any governing authorities prior to performing the work.

3.02. PREPARATION

A. Subgrade shall be prepared as per Section 301 of the IDOT Standard Specifications. Drains, utilities, and structures occurring in the area to be paved shall have been installed and/or adjusted prior to the work.

B. Provide the fine grading of prepared subgrade, final shaping, and compaction of the subgrade just prior to construction of the aggregate base course.

C. Prior to paving, verify all dimensions, limits and elevations, especially where required to meet and align with existing/proposed curbs and gutters and existing pavements and to provide for positive surface drainage.

3.03. APPLICATION OF BASE COURSE

A. Aggregate Base Course: Provide in accordance with IDOT Standard Specifications, (SSRBC) Section 351, "Aggregate Base Course".

1. HMA pavements shall be constructed on a six (6) inch granular base unless indicated otherwise and up to 3 inches greater in depth when adjacent to existing pavement; additional thickness shall be increased over 50 feet per Article 351.07 of the SSRBC.

2. Aggregate Base Course shall be placed on approved subgrade .

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3.04. PRIME OR TACK COAT

A. Prime Coat: Provide in accordance with IDOT Standard Specifications, (SSRBC) Section 406.05, HMA Binder and Surface Courses with the following modifications:

1. For placement on Aggregate Base Course, Prime Coat must cure at least 24 hours before HMA Binder level is applied.

3.05. HOT MIX ASPHALT

A. HMA Surface Courses: Provide in accordance with Standard Specifications, SSRBC Section 406, HMA Binder and Surface Course with the following modifications:

1. Minimum Marshall Stability shall be 1700

2. In areas inaccessible to rolling, compact by hand methods to produce the required density.

3. Where the previously primed base course or tacked binder course does not exhibit sufficient viscous qualities to secure proper adhesion of the surface course, apply a uniform tack coat of Grade RC-70 asphalt in accordance with Standard Specifications at the rate of 0.05 to 0.10 gallons per square yard, as directed by the CTA.

B. Asphalt Tack Coat: Provide tack coat as specified for "Prime Coat", except reduce the rate of application to 0.05 to 0.10 gallons per square yard. Allow tack coat to cure at least 24 hours before the next surface layer is applied.

C. Over Aggregate base course HMA surface course shall be 3-3/4” unless indicated otherwise on the drawings or required otherwise by the Standard Specifications. Where applicable, align new pavement with curb and gutter or existing pavement. Where matching existing pavement, decrease depth of HMA Binder course as necessary to match existing surface.

D. Compaction of Surface Courses

1. Compaction of surface course shall conform to Section 406.07. Begin rolling when mixture will bear roller weight without excessive displacement. Compact mixture while hot with hand tampers or vibrating plate compactors in areas inaccessible to rollers.

2. Breakdown Rolling: Accomplish breakdown or initial rolling immediately following rolling of joints and outside edge. Check surface after breakdown rolling, and repair displaced areas by loosening and filling, if required, with hot material.

3. Intermediate Rolling: Follow breakdown rolling as soon as possible, while mixture is hot. Continue second rolling until mixture has been thoroughly compacted.

4. Final Rolling: Perform final rolling while mixture is still warm enough for removal of roller marks. Continue rolling until roller marks are eliminated and course has attained maximum density.

E. All newly installed pavements shall align with existing adjacent pavement surfaces and sloped for proper drainage.

F. Protection: After final rolling, erect barricades to protect paving from traffic until it has sufficiently cooled and hardened such that there will be no rutting or shoving of the new pavement.

3.06. SEALCOATING

A. Contractor to sealcoat all new asphalt pavement after initial oils have been released from the asphalt. Follow manufacturer's recommendations and standard specifications for application of sealcoat, including amount of time to allow between installation of asphalt and application of sealcoat.

B. Installation of sealer for HMA surfaces to be according to Section 403 of the Standard Specifications.

C. Prepare asphalt surfaces by cleaning them of dirt, debris, stones, and other loose material. Clean by broom sweeping, vacuum, or other approved means. Pavement to be dry prior to installation of sealer.

D. Verify that acceptable atmospheric conditions will be present during the application and curing of the sealer; including the lack of moisture and freezing temperatures. Surface conditions of pavements to be sealed to be according to manufacturer’s recommendations.

E. Mix, if required, and prepare sealing material according to label directions.

F. Apply sealer in a uniform thickness according to ASTM D 3910. Apply strictly according to manufacturer’s directions at recommended thickness for maximum protection. Cover completely all surfaces to be sealed.

G. Take care not to get sealer on surfaces not to be sealed including curbs, gutters, sewers, manholes, catch basins, concrete surfaces, walls and vegetation. Legally dispose of used containers and equipment.

H. Allow sealer to cure and dry according to manufacturer’s directions and according to actual conditions. Only after verification that the sealer coat is completely dry, allow markings to be installed and then vehicular and pedestrian traffic to resume

END OF SECTION

SECTION 32 13 00
CONCRETE PAVING AND CURBS

PART 1 GENERAL

1.01. RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Special Conditions and Division 01 Specification sections, apply to this section.

1.02. SUMMARY

A. This work shall consist of constructing Portland Cement Concrete driveways and driveway pavement, to the limits shown on the drawings; including all forms, joints, scoring, joint filler, joint sealer, aggregate base and/or aggregate subbase required to complete this work as indicated.

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

1. Section 01 45 23 – Testing and Inspection Service.

2. Section 31 20 00 – Earthwork

1.03. REFERENCES

A. American Concrete Institute (ACI):

1. ACI 211.1, "Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete."

2. ACI 305, "Hot Weather Concreting".

3. ACI 306, "Cold Weather Concreting".

4. ACI 308, "Standard Practice for Curing Concrete".

B. Illinois Department of Transportation (IDOT): "Standard Specifications for Road and Bridge Construction (SSRBC), adopted January 2017 or latest edition., (IDOT), IDOT Supplemental Specifications and Recurring Special provisions adopted April 1, 2016.

1. Section 301 Subgrade Preparation

2. Section 311 Granular Subbase

Section 420 Portland Cement Concrete Pavement

3. Section 423 Portland Cement Concrete Driveway Pavement

4. Section 424 Portland Cement Concrete Sidewalks

5.

6. Section 1020 Portland Cement Concrete
7. Section 1021 Concrete Admixtures
8. Section 1022 Concrete Curing Materials
9. Section 1023 Protective Coat
10. Section 1051 Preformed Expansion Joint Fillers

C. Building Code, City of Chicago.

D. Additional Chicago Department of Transportation (CDOT): Rules and Regulations for Construction in the Public Way, March 2016 or latest edition.

1.04. SUBMITTALS

A. Certificates: Furnish certified test reports of the following:

1. Materials and Concrete Mix Designs: Certified report identifying the design mixes, stating where each mix will be used, the mix proportions, and additional design information including adjustments for seasonality or flowability of concrete. Certified test results, showing that the mix proportions and materials comply with the specified characteristics.
2. Admixtures: Certified test results and manufacturer's statements verifying that each admixture to be used in the work complies with specified requirements and is non-corrosive.

B. Quality Control Testing and Inspection Reports: Furnish reports for the specified Source Quality Control and Field Quality Control.

C. Product specifications: The contractor shall submit manufacturer's specifications for all relative products including expansion joint filler and sealer, indicating compliance with these specifications.

1.05. QUALITY ASSURANCE

A. Testing: Contractor shall arrange for and pay for an independent testing laboratory to perform the following tests; providing a copy of all reports to the CTA:

1. Design mix tests, air content test, slump test, compression tests.

PART 2 PRODUCTS

2.01. FORMS

A. Provide metal or wood forms conforming to profiles, lines and dimensions as shown, sufficient to maintain position and shape as concrete is placed.

2.03. CONCRETE MATERIALS

A. Portland Cement: ASTM C150. Type I standard cement for general construction.

B. Aggregate: ASTM C33. Gravel, crushed stone or sand.

C. Mixing Water: Potable.

D. Air Entraining Admixture: ASTM C260.

E. High Range Water Reducing Admixture (Superplasticizer): ASTM C494, Type F or G.

F. Non-Corrosive Accelerating Admixture: ASTM C494, Type C or E.

G. Water Reducing Retarding Admixture: ASTM C494, Type D.

H. Admixtures shall be used only with the CTA’s written approval. Curing and finishing materials shall be as approved by the CTA.

2.04. CURING AND FINISHING MATERIALS

A. Acrylic Curing Compound similar to Sonneborn Building Products "Kure-N-Seal" or approved equal.

2.05. JOINT FILLER

A. Preformed Expansion Joint Filler: Bituminous preformed joint filler conforming to IDOT Standard Specifications Section 1051; 1/2" thick unless noted otherwise; depth as required for concrete pavement.

2.06. CONCRETE MIX

A. Proportioning: Provide in accordance with ACI 211.1 requirements. Produce normal weight concrete of the type and strength indicated:

1. Minimum cement content: 6000 psi Mix: 540 lb/yd^3.

2. Maximum water-cement ratio: 0.45.

3. Slump: Maximum 3" slump at point of deposit.

B. Admixtures:

1. Air-Entraining Admixture: Provide for minimum 5% and maximum 7% air content.

2. High Range Water Reducing Admixture (Superplasticizer): Provide for exterior exposed concrete and concrete with a water-cement ratio of 0.50 or less, when approved by the Engineer.

3. Water Reducing (Accelerating) Admixture: Provide when concrete is to be placed at temperatures below 50 degrees F., when approved by the Engineer.

4. Water Reducing (retarding) Admixture: Provide when concrete is to be placed at temperatures above 85 degrees F., when approved by the Engineer.

2.07. READY MIXED CONCRETE

A. Provide in accordance with ASTM C94. Do not use the concrete if it undergoes initial set or is not deposited within 90 minutes after the water is introduced. Do not add water to unworkable concrete

PART 3 EXECUTION

3.01. 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.

B. The CTA shall be notified when the forms and reinforcement is in place but prior to pouring the concrete, for inspection of the subgrade, forms, and reinforcement.

3.02. SUBGRADE PREPARATION

A. Subgrade shall be prepared according to Section 301 of the IDOT Standard Specifications at the locations, lines, shapes, and dimensions required for the finished work. Provide the necessary final excavating and filling to prepare the finished subgrade.

B. Provide for any ramps in the pavement and sidewalks as shown on the drawings or as otherwise required by ADA or other code. Subgrade to allow for proper ramping to meet adjacent pavements and levels. Locate and provide for inlets, outlets, curb cuts and other obstructions or built in items.

C. Saw-cut existing concrete where required.

D. Drains, utilities and structures occurring in the area to have concrete shall have been installed. Separate concrete curb and gutter, if any, shall be installed prior to the installation of concrete pavements.

E. Verify all dimensions, limits and elevations, especially where required to meet and align with existing. Verify that proper elevations or the subgrade has been provided with proper slopes for drainage.

3.03. AGGREGATE SUB-BASE COURSE FOR CONCRETE WALKS, DRIVEWAYS, AND OTHER PAVEMENT

A. Construct aggregate sub base course in accordance with Section 311, Granular Subbase of the IDOT Standard Specifications. Type B material shall be used. Construct the base course in layers not exceeding 6" in thickness, and compact to not less than 100% of maximum density as determined by AASHTO T99.

B. Deposit the granular material directly on the prepared subgrade or on the preceding layer of compacted subbase with a mechanical spreader or spreader box. Place the material to be free from segregation and require minimum blading or manipulation. Compact each layer of material to not less than 100% of maximum density as determined by AASHTO T99. Make a final rolling on the top layer with a 3-wheel or tandem roller weighing from 6 to 10 tons, but not less than 200 pounds nor more than 325 pounds per inch of roller width.

C. If any subgrade material is worked into the subbase material during the compacting or finishing operations, remove the granular material within the affected area and replace with new aggregate. Restrict hauling over the completed or partially completed work after inclement weather or at any time when the subgrade is soft or there is a tendency for the subgrade material to work into the base material.

D. Compact each layer with the aid of water. Make moisture content sufficient to prevent segregation into pockets of fine and course material. When the aggregate is deficient in moisture content, add water before the material is placed on the subgrade.

E. A minimum of six (6) inches of sub-base granular material, type B, shall be placed below all concrete slabs, concrete side walk and under ADA ramps , driveways and driveway pavement in accordance with Section 311 of the Standard Specifications. .

3.04. FORMS

A. Carefully set forms in proper alignment and grade. Secure forms rigidly in place. Do not remove forms until concrete has sufficiently hardened.

5. Provide and install dowel bars at expansion joints. Size, spacing, lengths, bending, and other details for bars and dowels as shown on the standards or on the project drawings.

3.06. PLACING OF CONCRETE

A. No Portland Cement Concrete shall be placed until the subgrade and subbase have been approved by the CTA and/or regulating agency.

B. The granular subbase shall be moistened just before the concrete is placed.

C. Deposit concrete in such a manner as to require as little re-handling as possible; and distributed to such depth that when consolidated and finished, the required thickness will be maintained at all points.

D. Do not allow any portion of a batch of concrete to become segregated. If interruptions are necessary, make a construction joint.

E. Do not place concrete on a soft, muddy, or frozen base course. Do not place concrete around manholes, inlets, valve boxes or other structures until they have been brought to the required grade and alignment.

F. Deposit concrete in continuous operation, distribute and consolidate to required lines with proper compaction, eliminating any voids or “honeycombing”. Do not dislocate reinforcing materials while pouring and working concrete. If interruptions are necessary in concrete installation, provide for a construction joint.

G. Bring surface of concrete to required lines and cross-section by a strike-off guided by the side forms. Provide for all ramps, slopes, inclines, and other changes in elevation, etc. Pour continuously between expansion joints. Vibrate concrete as required for proper compaction, and to force the coarse aggregate down and to bring a layer of mortar to the top surface.

H. As soon as possible after consolidation, smooth and consolidate the concrete by floating and troweling. Provide for required profile and radiuses. Remove laitance and excess water from the surface. After completion of floating, and while the concrete is still plastic, test the surface with a 10' straightedge. Correct the surface variations exceeding 1/8" in 10 feet, except at grade changes or curves.

1. Unless indicated otherwise, the minimum thickness of sidewalks and ADA ramps shall be five (5) inches.

2. Unless indicated otherwise, the minimum thickness of pavement and driveways shall be six (6) inches

I. Where shown or required, provide ADA sidewalk ramps with depressed curbs per current CDOT Standard drawings. Provide detectable warning panels from CDOT approved list and per CDOT ADA Compliance and Transition Guidelines.

J. Provide slope and elevation for concrete paving for drainage and align and match existing adjacent pavements.

3.07. CONTRACTION JOINTS

A. Tooled Contraction Joints shall be placed at 10 foot intervals. Form contraction joints in the fresh concrete by cutting a groove in the top portion of the concrete by means of a radiused cutting blade. Finish all edges with a jointer. Make the completed surface uniform in color, free of surface blemishes and tool marks.

B. Sawed Contraction Joints (to control cracking): See drawings for locations of joints or, if not shown, at 5 foot intervals. Form sawed contraction joints by use of a power saw. Unless noted otherwise, make joint width 3/8" and depth not less than 1/4 of the slab thickness. Cut joints between 8 hours and 3 days after the concrete is placed, depending upon the mix of the concrete and weather conditions. Where required, seal the joint with joint sealer.

3.08. EXPANSION JOINTS

A. Expansion Joints in Pavement: Provide expansion joints at all intersections with other pavements, at existing walks or pavements, light standards, at buildings, at columns, at abutments with steps or other structures, at 30' intervals max. and at other locations where indicated or required. Expansion joint to be of thicknesses 3/4". Expansion joints to be continuous and for the full depth of the slab. Construct expansion joints at right angles to the building and align with expansion joint in slab. Fill expansion joints with the required joint filler strip held in place to prevent warping of the filler during concrete placing, floating and finishing operations. Provide dowels and metal sleeves in expansion joints as required. After finishing operations are completed, round the joint edges with an edging tool and clean the concrete from joint opening.

3.09. PROTECTION FROM WEATHER

A. Hot Weather Protection: Provide in accordance with ACI 305 requirement to control concrete procedures when air temperature or form temperature exceeds 100 degrees F.

B. Cold Weather Protection: Provide in accordance with ACI 306 requirements to control concrete procedures when mean daily temperatures are expected to drop below 40 degrees F.

3.10. CONCRETE CURING PROCEDURES

A. Curing Period: Provide in accordance with ACI 308. Retain moisture and maintain reasonably constant temperature in concrete for the duration of the curing period, starting at time of deposit for 5 days.

B. Concrete Surface Curing Temperature: Minimum 50 degrees F., maximum 90 degrees F. Rate of change: maximum plus or minus 5 degrees F. per hour.

C. Curing Materials: Provide in accordance with the manufacturers' recommendations. Use the products of a single manufacturer for curing and sealing materials to be applied sequentially on same substrate. Where products of different manufacturers are used, confirm compatibility of the materials with the manufacturers. Mask areas to receive joint sealants before application of curing or sealing agents.

3.11. FINISHING OF CONCRETE

A. Finish Pavement and Drivewaysper section 423.06 of the IDOT Standard Specifications. The surface shall be finished to grade and cross-section by suitable floats. After floating, trowel as required to produce a smooth, dense surface. Finish panels between joints with a fine-hair broom drawn over the surface transverse to line of traffic. Apply acrylic curing compound. Ramp and provide any textured finish shown on the drawings or as otherwise required by ADA or other codes.

B. Cleaning: After concrete has fully cured, thoroughly clean the concrete surfaces to remove dirt, loose material, oil, grease, curing compounds, and deleterious substances that would prevent proper bond of surface sealers or joint sealants.

3.12. REMOVAL OF FORMS

3.13. REPAIR

A. General: Repair concrete 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. Remove and replace defective sections between the nearest contraction or expansion joints. Protect the work from damage until accepted.

3.14. FIELD QUALITY CONTROL

A. Air Content Test: ASTM C173. Every 100 cubic yards at random.

B. Slump Test: ASTM C 143. Make 2 tests for each 100 cubic yards of concrete or fraction thereof, but not less than 2 tests for each day's pour, and make each test from a separate batch. Provide a slump cone and rod available for use at all times.

C. Compression Tests: ASTM C31 and C39. Sample at point of deposit. Cure the cylinders in laboratory. Make 1 set of 5 standard 6" x 12" cylinders for every 100 cubic yards or fraction thereof, but not less than 1 set of cylinders for each day's pour and only 1 set of tests from any one batch of concrete. Test 2 cylinders at the age of 7 days, 2 cylinders at the age of 28 days, and keep 1 cylinder in reserve for 56-day test if 28 day test results do not meet requirements. In addition, make 1 cylinder from every truck load and test at the age of 7 days.

D. Compression Tests Reports: Provide reports to the CTA, certified by the independent testing agency, including the following information: Job name, contractor, supplier; mix and required strength; pour location; slump, air content, truck number, time and date sampled, air temperature, concrete temperature, consistency; curing history; date tested; compressive strength; type of fracture; compliance with specification.

E. Additional Testing and Inspection: In addition to specified testing, Contractor is responsible for the expense of additional testing or inspection resulting as a consequence of the work not evidencing compliance with this specification; including taking, curing, and testing of concrete cores.

F. See Section 01 44 80, “Testing and Inspection Service’ for tests required for concrete paving and curbs.

END OF SECTION

SECTION 32 31 13
CHAIN LINK FENCING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Special Conditions and Division 1 Specification sections, apply to this section.

1.02 SUMMARY

A. This Section includes providing and installing site improvements including:
   1. Chain Link Fence.
   2. Swing Gates.
   3. Overhead Horizontal Slide Gate

B. This section specifies requirements for furnishing and erecting variable height chain link fencing and swing or horizontal slide gates up to a maximum twelve (12) foot height and including all poles, framing, fabric, and hardware as shown on the drawings or as otherwise required or directed.

C. Related work specified elsewhere includes:
   1. Section 03 30 00 - Cast-in-Place Concrete
   2. Section 31 20 00 – Earthwork

1.03 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 specification sections.

B. Shop Drawings: Submit for review and approval shop drawings for the fabrication and installation of all items. Show plans, elevations, sections, and details for each type of fence and gates. Show installation details for each type of fence and gate and for each type of condition. Show concrete support, posts, rails, fencing design, gates. Indicate gate operation and hardware. Indicate heights of fencing, and all field verified dimensions, elevations and conditions. Indicate if it will be necessary to step height of fencing due to grade elevation changes, either accumulative or at specific points.

C. Indicate on shop drawings plans, elevations and details for gates. Indicate single and double gates. Indicate size (width and height), direction of operation, construction, support posts at each side, reinforcing and all hardware including hinges, latch, lock, pulls or knobs, closer and other items. Indicate on shop drawings field verified dimensions and conditions. Provide a copy of a recent survey indicating property line dimensions.

D. Structural Calculations: Signed and Sealed by Structural Engineer licensed in the state of Illinois showing required sizes for slide gate and framing.

E. Samples: Submit finish and color samples for chain link fencing materials, including posts, framing, mesh and hardware. Provide samples of actual materials as requested by Authority.

F. Product Data: Submit technical data for all materials. Indicate diameters, sizes, and thicknesses of metal for all posts and rails; type and gauge of mesh; hardware specs for gates. Indicate sizes and types for stretcher bars, tension wire and braces. Indicate attachment devices; end caps and other accessories. Indicate specifications for galvanizing, coating types, and finishes.

G. Supplementary Product Literature: Furnish manufacturer’s literature describing the general properties of each product to be used.

1.04 QUALITY ASSURANCE

A. Contractor is solely responsible for quality control of the materials and installation.

B. Regulatory Requirements: Comply with applicable requirements of the laws, codes, ordinances and regulations of Federal, State and Municipal authorities having jurisdiction. Obtain necessary approvals from all such authorities for placement and installation of all fencing.

C. Chain link fencing materials and construction shall conform to the applicable portions of Section 664 of the I.D.O.T. Standard Specifications.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store materials in manufacturer=s original packaging labeled to show name, brand, type, and grade. Store materials in protected dry location off ground in accordance with manufacturer’s instructions. Do not open packaging nor remove labels until time for installation.

1.06 PROJECT CONDITIONS

B. Locate existing underground utilities and other site improvements before starting installation of piers for fencing. Survey site for any possible obstructions in fence line and necessary clearances. Determine subsurface and surface conditions for installation of piers. Verify grades and determine elevation required for level installation of horizontal members.

C. Field Measurements: Verify lay-out information for chain-link fences and gates shown on drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

D. 5 year warranty from the date of official acceptance.

PART 2 PRODUCTS

2.01 CONCRETE AND RELATED MATERIALS

A. Concrete and related materials are specified in Division 03 Sections.

2.02 CHAIN LINK FENCE MATERIALS

B. Fence Fabric: Zinc coating in accordance with ASTM A 392, Type II, Class 2, 2.0 oz/sq.ft. Provide 2" diagonal mesh of wire, 0.192 inch diameter with Barber selvage.

C. Posts and Framing Size and Thickness: Posts in accordance with ASTM F 1083 for pipe; framing in accordance with ASTM F 1043, unless indicated otherwise.

1. Steel Pipe: ASTM F 1083, Schedule 40, with not less than 1.8 oz./ft2 zinc coating of surface area coated.
2. End, Corner, and Pull Posts: Steel pipe. Size as indicated on Drawings, minimum 3" O.D. with a .160 wall thickness for fences up to 10’ in height.
3. Line and Intermediate Posts: Steel pipe. Size as indicated on Drawings or 2 1/2"

O.D. with a .130 wall thickness for fences up to 10' in height.

4. Swing Gate Posts: According to ASTM F900 for steel pipe. Size as indicated on Drawings, minimum 2-1/2" O.D. with a .130" wall thickness.
5. Horizontal-Slide Gate Post: According to ASTM F 1184. According to ASTM F900 for steel pipe. Size as indicated on Drawings, minimum 4" O.D. with a .130 wall thickness.
6. Top Rails: Steel pipe, 1 5/8" O.D. with a .111 wall thickness. Provide with couplings and fittings for attachment to posts.
7. Center and/or Bottom Rails: Same as top rail.
8. Gate Frame: 1" diameter pipe.

D. Fittings and Accessories: In accordance with ASTM F 626. Provide components necessary for a complete installation. Hot dipped galvanized finish unless otherwise specified.

1. Caps: Caps for posts and rails manufactured from steel or cast iron with hot dipped galvanized finish. Weathertight design for use on top of posts.
2. Tension and Stretcher Bars: One bar for each gate and end post and 2 bars for each corner and pull post. Hot dipped galvanized finish. Minimum 1/4" x ¾” flat steel.
3. Stretcher Bar Bands: Galvanized flat steel bar not less than 1/8" x 1" with 3/8" galvanized carriage bolt.
4. Brace: Horizontal member approximately 1/3 the height distance from top, secured to posts, at both sides of terminal (pull) posts, corner posts, and at fence side of gate posts. Brace to be 1-5/8” deep channel with 1-1/4” web, 0.0747 thick galvanized metal.
5. Tie Wire: 12 gage galvanized steel with ASTM F 626, Class 3 zinc coating.
6. Tension Wire, top and bottom: 0.177 inch diameter ASTM A817, ASTM A 824 Type II not less than 2 oz/ sq.ft. of uncoated steel wire surface galvanized with turnbuckles.
7. Truss Rods: One diagonally at ends, two diagonally at gates. Galvanized steel rod and turnbuckle assembly.

E. Gates: Use 1" diameter steel pipe frame in accordance with ASTM F 1043 and ASTM F 1083, Schedule 40, with not less than 1.8 oz./ft2 zinc coating of surface area coated. Assemble gates by welding framing members. Use truss rod cross bracing to prevent sagging.

1. Fabric Height: Two inches less than adjacent fence height.
2. Hardware: Provide operating hardware including hinges (90 deg. for pedestrian gate, 180 deg. for vehicle gate), gate latch to accommodate padlock, plunger rod with latch with provision for locking, and foot bolt with keeper for each gate leaf to hold gate in open position. Galvanized finish in accordance with ASTM A 153.
3. Rolling gate mechanism, rollers, latch, stop, for sliding gate operation.

F. Swing gates: Comply with ASTM F 900. Welded frame corner construction; 5/16 inch diameter adjustable truss rods for panels 5 feet wide or wider.

1. Latches to permit operation from both sides of gate, hinges and keepers for each gate leaf.

G. Overhead Horizontal-Slide Gates: Comply with ASTM F 1184. Use Type II slide, Class I roller assemblies. Fabricate framing with 2-1/2” galvanized steel tubing size as indicated herein, on drawings, or required to meet specifications. Welded frame with 5/16 inch diameter adjustable truss rods for panels 5 feet wide or wider.

1. Roller Guards as required per ASTM F 1184 for Type II, Class I gates. Latches

permitting operations from both sides of gate, roller assemblies, hangers, stops, guide roller assemblies and locking devices fabricated from galvanized steel with stainless steel fasteners. Fabricate latches with integral eye openings for padlocking.

2. Overhead horizontal slide gate posts to be double 6” diameter min. posts

2.03 FINISHES

A. All metal to be used for chain link fencing, including all posts, fabric, pipes, accessories, wires, etc. to be hot dip galvanized to meet requirements of ASTM A 653/A 653 M with a minimum zinc coating weight of .90 ounces per square foot (coating Designation G-90), hot dip process.

PART 3 EXECUTION

3.01 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.

B. Extent of work including height of fencing, size and location of gates, as shown on the drawings. Layout, dimensions and elevations at site for fencing to be verified in the field. Verify locations of obstructions and any other site conditions affecting installation.

3.02 GROUND PROTECTION

A. Ground protection shall be included on all fencing. All ground wire shall be a 6 gauge solid, bare copper wire conforming to ASTM B33. The ground wire shall be secured to the fabric and posts with clamps, connectors or other fasteners as approved by the Authority. The ground wire shall be secured to the stainless steel rod by means of a bronze clamp as approved by the Authority. The rod is to be embedded into the ground. The grounding system shall be complete, uninterrupted and installed as shown on IDOT Standard 2168.

3.03 FENCE INSTALLATION

A. General: Install in accordance with manufacturer’s instructions. Space posts as indicated on Drawings. Install components with secure attachment, true to line, plumb and level.

B. Posts Set in Concrete: Set posts and gate stops in ground in concrete encasements. Excavate for posts in undisturbed or properly compacted soil. Holes for posts shall be diameter equal to four times the outside diameter of the post and depth of 6" greater than the depth of the post. Concrete piers shall extend a minimum of 42" below grade. Use air-entrained, normal weight concrete having 28 day compressive strength of 4,000 psi, placed in a continuous pour with top surface 2" above grade and sloping away from post to shed water and troweled smooth. Provide for required height of fence post. Support and protect posts until set.

C. Provide 10 inch in diameter, 22 inch minimum concrete pier for gate stop flush with ground.

3.05 CHAIN LINK FENCE INSTALLATION

A. General: Install in accordance with ASTM F 567. Space posts uniformly and as shown on drawings and not to exceed 8'-0" o.c. Posts to be set plumb, aligned, and at correct height and spacing. Hold in position until set. Install components with secure attachment, true to line, plumb and level.

B. Terminal Posts: Locate terminal end, corner, and gate posts per ASTM F 567 and terminal pull posts at changes in horizontal or vertical alignment.

C. Line Posts: Space line posts uniformly.

D. Post Bracing and Intermediate Rails: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Install braces at end and gate posts and at both sides of corner and pull posts.

1. Locate horizontal braces at midheight of fabric 6 feet or higher, on fences with top rail and at 2/3 fabric height on fences without top rail. Install so posts are plumb when diagonal rod is under proper tension.

E. Tension Wire: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Pull wire taut, without sags. Fasten fabric to tension wire with 0.120-inch-diameter hog rings of same material and finish as fabric wire, spaced a maximum of 24 inches O.C. Install tension wire in locations indicated before stretching fabric.

1. Top Tension Wire: Install tension wire through post cap loops.
2. Bottom Tension Wire: Install tension wire within 6 inches of bottom of fabric and tie to each post with not less than same diameter and type of wire.

F. Top Rail: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Run rail continuously through line post caps, bending to radius for curved runs and terminating into rail end attached to posts or posts caps fabricated to receive rail at terminal posts. Provide expansion couplings as recommended in writing by fencing manufacturer.

G. Bottom Rails: Install, spanning between posts.

H. Bracing: Provide horizontal pipe brace at mid-height at each side of terminal posts and install diagonal truss bracing at these locations. Adjust truss rods to ensure posts remain plumb.

I. Chain-Link Fabric: Apply fabric to inside or outside (as shown or directed) of enclosing framework. Leave 3 inch between finish grade or surface and bottom selvage, unless otherwise indicated. This distance may vary with uneven ground. Pull fabric taut and tie to posts, rails and tension wires. Anchor to framework so fabric remains under tension after puling force is released.

J. Tension or Stretcher Bars: Thread fabric through entire length of tension or stretcher bars and secure stretcher bars to end, corner, pull, and gate posts with galvanized tension bands spaced not more than 15 inches O.C. vertically.

K. Tie Wires: Use wires of proper length to firmly secure fabric to line posts and rails. Attach wire at 1 end to chain-link fabric, wrap wire around post a minimum of 180 degrees, and attach other end to chain-link fabric per ASTM F 626. Bend ends of wire to minimize hazard to individuals and clothing.

1. Maximum Spacing: Tie fabric to line posts at 12 inches O.C. and to braces at 24 inches O.C. horizontally.

L. Fasteners: Install nuts for tension bands and carriage bolts on the side of the fence opposite the fabric side.

3.06 GATE INSTALLATION

A. Install gates according to manufacturer's written instructions, level, plumb and secure for full opening without interference. Attach fabric as for fencing. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Drill hole(s) in pavement for plunger rod and/or foot bolt as required. Adjust hardware for smooth operation and lubricate where necessary.

3.07 GROUNDING AND BONDING

A. Fence Grounding: Install at maximum intervals of 1500 feet except as follows:

1. Fences within 100 feet of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 750 feet.

a. Gates and Other Fence Openings: Ground fence on each side of opening.
1) Bond metal gate posts.
2) Bond across openings, with and without gates, except at openings, indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least 18 inches below finished grade.

B. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at maximum distance of 150 feet on each side of crossing.

C. Fences Enclosing Electrical Power Distribution Equipment: Ground as required by IEEE C2, unless otherwise indicated.

D. Grounding method: At each grounding location, drive a grounding rod vertically until the top is 6 inches below finished grade. Connect rod to fence with No.6 AWG conductor. Connect conductor to each fence component at the ground location.

E. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.

F. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
2. Make connections with clean, bare metal at points of contact.
3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
4. Make aluminum-to-galvanized-steel connections with tin plated copper jumpers and mechanical clamps.
5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

G. Bonding to Lightning Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning protection down conductor or lightning protection grounding conductor complying with NFPA 780.

3.08 FIELD QUALITY CONTROL

A. Grounding-Resistance Testing: If required by the Authority, engage a qualified independent testing and inspecting agency to perform field quality-control testing.

1. Ground-Resistance Tests: Subject completed grounding system to a megger test at each grounding location. Measure grounding resistance not less than two full days after last trace of precipitation, without soil having been moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural grounding resistance. Perform tests by two-point method according to IEEE 81.
2. Excessive Grounding Resistance: If resistance to grounding exceeds specified value, notify Architect promptly. Include recommendations for reducing grounding resistance and a proposal to accomplish recommended work.
3. Report: Prepare test reports certified by a testing agency of grounding resistance at each test location. Include observations of weather and other phenomena that may affect test results.

3.09 ADJUSTING

A. Upon completion of the Work, repair surfaces that have been permanently stained, marred, or otherwise damaged. Replace Work which is damaged or cannot be adequately cleaned as directed.

B. Gate: Adjust gate to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

3.10 CLEANING

A. Upon completion of the Work, remove unused materials, debris, containers and equipment from the project site. In addition to the initial cleaning procedure required, and not more than two days before occupancy by the Authority, clean the Work as recommended by the manufacturer.

3.10 PROTECTION

A. Protect the Work during the construction period so that it will be without any indication of use or damage at the time of acceptance.

END OF SECTION

SECTION 32 31 15
STEEL PLATE BEAM GUARDRAIL

PART 1 GENERAL

1.01. SUMMARY

A. This specification covers the furnishing and installation of materials for steel plate beam guardrail. Installation procedures shall be in accordance with the product manufacturer's recommendations, I.D.O.T. Standard Specification Section 630, and I.D.O.T. Standard 630001-10. Demolition and removal of materials shall be as required to support the work.

B. Related work specified elsewhere includes:

1. Section 01 11 00 – Summary of Work

2. Section 02 05 00 – Demolition

1.02. SUBMITTALS

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

1. Product Data: For each type of product indicated.

2. Shop drawings shall be submitted for approval.

1.03. QUALITY ASSURANCE

A. Obtain all materials from a single manufacturer.

B. Steel Plate beam Guardrail and Posts shall conform to the applicable portions of Section 630 of the I.D.O.T. Standard Specifications.

C. Contractor is solely responsible for quality control of the materials and installation.

D. Minimum 5-year warrantee from date of official acceptance.

1.04. DELIVERY, STORAGE, AND HANDLING

A. In order to prevent rapid oxidation of the zinc coating, all galvanized rail elements, end sections, splice plates, posts, and accessories shall be protected from rain, snow and other weathering conditions while they are stored prior to installation. This protection shall consist of storing the galvanized parts of the guardrail off the ground surface, so that it will not come in contact with surface runoff water, and properly covering the parts on top and all sides. Care shall be taken to avoid any collection of moisture between elements while in storage.

1.05. PROJECT CONDITIONS

A. Locate existing underground utilities and other site improvements prior to commencing construction operations. Survey site for any possible obstructions in line and necessary clearances. Determine subsurface and surface conditions for installation of posts. Verify grades and determine elevation required for level installation of horizontal members.

B. Field Measurements: Verify lay-out information for steel plate beam guardrail shown on drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

PART 2 PRODUCTS

2.01. MATERIALS

A. Rail Elements, End Sections, and Fasteners

1. Steel Plate Beam Guardrail material shall be in accordance with I.D.O.T. Standard Specification Section 1006.25.

2. Provide galvanized steel plate beam guardrail in accordance with AASHTO M-180, class A, with type II galvanized coating.

3. Shop curve rail elements when required radius of installation on horizontal curve is 150 ft (46 m) or less.

4. Provide end section at each end of installation.

5. Provide standard back-up plates behind rail elements at all intermediate, non-splice posts when steel posts and blocks are used.

B. Posts

1. Steel posts material shall be in accordance with I.D.O.T. Standard Specification Section 1006.23.

2. Fabricate posts from W6X9 structural steel shapes complying with the requirements of AASHTO M 270 Grade 36. Fabricate in the shop, grind smooth all corners and edges, galvanize posts after fabrication in accordance with AASHTO M 111.

C. Bolts, Nuts, and Washers

1. Provide galvanized bolts, nuts, and washers in accordance with AASHTO M-180. Provide bolts with rounded heads to provide minimum obstruction.

2. Provide galvanized steel bolts conforming to the requirements of ASTM A 307, nuts conforming to the requirements of ASTM A 563, Grade A or better and galvanized steel washers, all galvanized in accordance with the requirements of ASTM A 153.

D. Reflectors: Provide guardrail reflectors as indicated.

1. For guardrail adjacent to alley ways, place Type A reflector at every post in accordance with IDOT Standard 635011-02. Refer to detail drawings.

2. For guardrail adjacent to building, place adhesive retroreflective sheeting continuously along guardrail rail including end sections. Refer to detail drawings.

E. Blockouts:

1. Wood Blocks shall be in accordance with applicable sections of I.D.O.T. Standard Specification Section 1007.01, 1007.02, and 1007.06.

PART 3 EXECUTION

3.01. 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.

B. Extent of work including height of guardrail, size and location of posts, as shown on the drawings. Layout, dimensions and elevations at site for guardrail to be verified in the field. Verify locations of obstructions and any other site conditions affecting installation.

3.02. POST INSTALLATION

A. General: Install in accordance with manufacturer’s instructions. Space posts as indicated on Drawings. Install components true to line, plumb and level.

B. Posts shall be installed to a typical minimum depth of 40-1/8 inches. See detail drawing for requirements.

C. Posts Set in Aggregate: When impervious material is encountered, posts shall be set in aggregate backfill (CA 11). See detail drawings for requirements.

D. Post Spacing: Posts shall be set at 6’ 3” typical spacing. See detail drawings for requirements.

3.03. CLEANING

A. Upon completion of the Work, remove unused materials, debris, containers and equipment from the project site. In addition to the initial cleaning procedure required, and not more than two days before occupancy by the Authority, clean the Work as recommended by the manufacturer.

3.04. PROTECTION

A. Protect the Work during the construction period so that it will be without any indication of use or damage at the time of acceptance.

END OF SECTION

SECTION 32 31 25
BOLLARDS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Special Conditions and Division 01 Specification sections, apply to this section.

1.02 SUMMARY

A. This work shall consist of constructing Concrete Filled Steel Pipe Bollards in locations as indicated on plans.

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

1. Section 01 45 23 – Testing and Inspection Service.
2. Section 31 20 00 – Earthwork
3. Section 32 13 00 - Concrete Paving and Curbs

1.03 REFERENCES

A. American Concrete Institute (ACI):

1. ACI 211.1, "Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete."
2. ACI 301, "Specifications for Structural Concrete for Buildings"
3. ACI 305, "Hot Weather Concreting".
4. ACI 306, "Cold Weather Concreting".
5. ACI 308, "Standard Practice for Curing Concrete".

B. American Society of Testing and Materials (ASTM):

1. ASTM A53: Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless

C. Illinois Department of Transportation (IDOT): "Standard Specifications for Road and Bridge Construction (SSRBC), adopted January 1, 2012, (IDOT), IDOT Supplemental Specifications and Recurring Special provisions adopted January 1, 2015,

1. Section 1006 Metals
2. Section 1020 Portland Cement Concrete
3. Section 1024 Grout and Nonshrink Grout

D. Building Code, City of Chicago.

1.04 SUBMITTALS

A. Certificates: Furnish certified materials reports of the following:

1. Steel posts
2. Concrete and Grout

B. Quality Control Testing and Inspection Reports: Furnish reports for the specified Source Quality Control and Field Quality Control.

C. Product specifications: The contractor shall submit manufacturer's specifications for all relative products.

D. Submit shop drawings showing materials and installation of bollards.

1.05 FIELD MEASUREMENTS

A Make field measurements to ensure that bollards are installed in the proper location, and in correct relationship to the adjacent facilities. Where bollards are designed to protect other construction, check actual dimensions of the other construction to verify the suitability of positioning.

1.06 PROJECT CONDITIONS

A. Locate existing underground utilities and other site improvements prior to commencing construction operations. Survey site for any possible obstructions in line and necessary clearances. Determine subsurface and surface conditions for installation of posts. Verify grades and determine elevation required for level installation of horizontal members.

B. Field Measurements: Verify lay-out information for bollards shown on drawings in relation to existing structures. Verify dimensions by field measurements.

PART 2 PRODUCTS

2.01 BOLLARDS

A. POSTS: Provide galvanized and prime coated, standard weight steel pipe as specified in ASTM A53, size as shown on plans.

B. FOUNDATION: Provide Class SI concrete (per Section 1020 of the IDOT SSRBC) for post footing/foundation

C. GROUT: Provide Nonshrink Grout (per Section 1024 of the IDOT SSRBC) for filling annular cavity of steel bollard

PART 3 EXECUTION

3.01 INSTALLATION

A. Install bollards in accordance with the plans and approved shop drawings. Anchor after posts have been inserted into holes, fill annular space with nonshrink grout.

3.02 CLEANING AND PROTECTION

A. Upon completion of the Work, remove unused materials, debris, containers and equipment from the project site.

B. Protect the Work during the construction period so that it will be without any indication of use or damage at the time of acceptance.

END OF SECTION

SECTION 32 90 00
LANDSCAPING

PART 1 GENERAL

1.01. RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Special Conditions and Division 01 Specification sections, apply to this section.

1.02. SUMMARY

A. General: Provide Landscaping in accordance with requirements of the Contract Documents. Landscaping for this project includes soil and planting materials for planting bed.

B. Plant materials as indicated on the drawings.

1. Shrubs.
2. Hardwood Bark Mulch.
3. Planting Mixture and Fertilizer.
4. Weed Barrier.
5. Gravel and Stone.
6. Planter Liner.
7. Sod.

C. Related Work specified elsewhere includes:

1. Section 31 20 00, Earthwork.

1.03. SUBMITTALS

A. Procedures: Furnish submittals in accordance with general requirements specified in Division 01 Section, Submittal Procedures.

1. Provide submittals for all planting materials including shrubs, grass, sod, fertilizers, weed barrier, mulch and gravel or stone.

B. Product Data: Furnish a material list with technical data documenting the primary function, quality, and performance of each system to be used in the Work, e.g., the plant species and sizes, fertilizer analysis, soil amendment materials or other such primary characteristics as required by the Drawings or Specifications.

1. Furnish names and addresses of proposed suppliers for plant materials with listing of plants to be obtained from each source.

2. Within 20 days following acceptance of nursery sources, submit documentation that plant material has been ordered. Indicate size of plants as well as container size on order form.

C. Supplementary Product Literature: Furnish manufacturer's literature describing the general properties of each product to be used in the Work, weed barriers, planter liners, etc.

1. Provide shop drawings indicating details for the installation of the plant liner system, if necessary.

D. Certifications: Furnish certifications for the following.

1. Certificates of Inspection: Certificates of inspection as required by governmental authorities.
2. Soil Amendments and Fertilizer: Manufacturer's or supplier's certified analysis for soil amendments and fertilizer materials.

E. Quality Control Testing and Inspection Reports: Furnish reports for specified Quality Control inspections and tests.

F. Planting Schedule: Indicating anticipated planting dates for exterior plants.

G. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of exterior plants during a calendar year. Submit before expiration of required maintenance periods.

H. Provide information about the firms installing the landscape products and related products indicating their experience and as required by the Quality Assurance section of this specification.

1.04. QUALITY ASSURANCE

A. Installer: Firm with minimum of 4 years successful experience in landscaping of similar scope.

1. Related products such as weed barrier and planter liner shall be installed by firms experienced in the installation of that product and approved by the manufacturer to install the product.

B. Plant Material: Quality and size of nursery stock shall conform to regulations of ANSI Z 60.1, "American Standard for Nursery Stock".

C. Nomenclature: Plants shall conform to current standards for horticultural nomenclature. Plants shall be true to name.

D. Provide quality, size, genus, species, and variety of exterior plants indicated, complying with applicable requirements in ANSI Z60.1, American Standard for Nursery Stock.

E. Shrub Measurements: Measure according to ANSI Z60.1 with branches and trunks or canes in their normal position. Do not prune to obtain required sizes. Measure main body of shrub for height and spread; do not measure branches or roots tip-to-tip.

F. Observation: Architect may observe shrubs either at place of growth or at site before planting for compliance with requirements for genus, species, variety, size, and quality. Architect retains right to observe shrubs further for size and condition of balls and root systems, insects, injuries, and latent defects and to reject unsatisfactory or defective material at any time during progress of work. Remove rejected shrubs immediately from Project site.

G. Notify Authority of sources of planting materials 7 days in advance of delivery to site.

H. Pre-installation Conference: Conduct conference at project site to review installation conditions, locations, etc.

1.05. DELIVERY, STORAGE, AND HANDLING

A. Labeling of Materials: Mark plants, prior to delivery to site, with correct botanical names, using durable, legible labels. Plants not labeled by nursery of origin are not acceptable. Keep plants of different species and varieties separated at site.

B. Weather: When weather conditions are such that exposure to sun and wind during transit may adversely affect health of plants, transport plant materials to site in controlled environment trailer. Use carrier experienced in handling live plants.

C. Protection: Protect materials from deterioration during delivery and while stored at site. Adequately protect plants from drying out, exposure of roots to sun, and from other injury. If planting is delayed more than 24 hours after delivery, set plant material in shade and keep roots moist. Heel in bare root stock. Protect roots of balled and burlapped plants with soil, wet moss, or other acceptable material. Do not remove container grown stock from containers until planting time.

D. Digging: Balled and burlapped (B&B) plants shall be dug with a firm rootball of natural earth, of a size in proportion to the plant's size, as measured by caliper, height, or spread.

E. Handling: Balled and burlapped plants shall be handled only by the rootball, not by the trunk or branches, as this may break or loosen the rootball and damage the root system.

1. Do not handle, move, bind, tie or otherwise treat plants so as to damage the rootball, roots, trunk, or branches in any way.

1.06. PROJECT/SITE CONDITIONS

A. Existing Conditions: Exercise caution against injury to, or defacement of, existing conditions. Repair or replace items damaged from installation operations. Maintain finish grades and indicated flow lines in planting areas. Provide positive drainage with no standing water.

1.07. SEQUENCING AND SCHEDULING

A. General: Prior to starting the Work, prepare a detailed schedule of the Work for coordination with other trades. Prepare planting schedule in accordance with normal planting time of specified plant materials.

1.08. WARRANTY

A. Plant Materials Warranty: Furnish written warranty in form stipulated by Authority, signed by the Contractor and Installer, agreeing to replace defective Work which has failed as a result of defects in the growth or health of the plant materials. Defective plant materials are defined as plant materials that are dead or not in healthy attractive condition. Upon notification of such defects, within the specified warranty period, make necessary replacement at the convenience of the Authority. Provide replacement plant materials of same kind and to closely match adjacent plant material of same species.

1. Plant materials: 12 month warranty.

B. Provide an inspection of all landscaping materials at the eleventh month to access the healthy growth of the materials.

C. Remove dead plants and/or sod immediately. Replace immediately unless required to plant in the succeeding planting season.

2. Replace exterior plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.

3. A limit of one replacement of each exterior plant will be required, except for losses or replacements due to failure to comply with requirements.

1.09. MAINTENANCE

A. Maintenance Instructions: Furnish complete instructions describing the materials, devices and procedures to be followed in maintaining the Work. Include manufacturers' brochures and material lists describing the actual materials used in the Work. Include procedures to be established by Authority during warranty period. Include instructions for fertilization, mechanical and chemical weed control, control of insects and diseases, cultivation, pruning, erosion control, and other necessary horticultural practices.

B. Shrubs: Maintain for the following maintenance period by pruning, cultivating, watering, weeding, fertilizing, and resetting to proper grades or vertical position, as required to establish healthy, viable plantings. Spray as required to keep shrubs free of insects and disease.

1. Maintenance Period: 12 months from date of Substantial Completion.

PART 2 PRODUCTS

2.01. PLANT SCHEDULE

A. See drawings for plant material schedule for type, species, size and other information for planting materials. See drawings for locations for plant materials.

2.02. SHRUB MATERIAL

A. General: Furnish nursery-grown shrubs conforming to ANSI Z 60.1, 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.

1. Grade: Provide shrubs of sizes and grades conforming to ANSI Z 60.1 for type of shrubs required. Shrubs of a larger size may be used if acceptable to Authority, with a proportionate increase in size of roots or balls.

2. Label each shrub with securely attached, waterproof tag bearing legible designation of botanical and common name.

B. Source: Plant materials shall be nursery-grown in accordance with good horticultural practices and shall have been transplanted or root-pruned at least once in the 2 year period immediately preceding the growing season during which they are to be installed.

1. Restrictions: Provide only plants from State inspected nurseries.

2. Climate: Plants shall have been grown in a climate similar to Chicago's, i.e., United States Department of Agriculture (most recent USDA zone hardiness map) zone 4 or 5 (zone 5 are generally hardy only near the warming influence of Lake Michigan). Plants from zone 6 B or more, i.e., warmer climate zones, are not acceptable.

C. Pruning: Do not prune plants prior to delivery.

2.03. MATERIALS FOR PLANTING OPERATIONS

A. Planting Soil: Planting soil shall be imported, shall be friable and free of deleterious material. For use as supplement to existing site soil in planting areas not on structure. After completing soil tests on site soil, select import soil with similar physical properties. Provide material with a pH between 6.0 and 6.5, free from sewage sludge, manure, sticks, stones larger than 1", and other debris and free from noxious weed seed and other deleterious plant and animal life. Used greenhouse or nursery soil is not acceptable. Do not deliver in muddy or frozen condition. Soil shall be 70% topsoil, 10% sand, 10% sphagnum peat moss and 10% well rotted cow manure.

B. Sand: Coarse, clean, washed, of F2 graduation. Maximum salinity not greater than 3 mmhos/cm. pH 7-0 or less. SAR 4 or less. Boron 0.75 or less.

C. Mulch: Shredded hardwood bark of even consistency, intended for horticultural use and containing less than 2% non-bark wood particles.

D. Soil Amendments:

1. Sphagnum Peat Moss: Partially decomposed vegetable matter. Clean, low in content of mineral and woody material. Finely shredded. Organic content 90 to 100% (dry weight), pH 3.5 to 5.5, nitrogen 0.6 to 3.0%. Maximum salinity 3.0 mmhos/cm.
2. Manure:

a. Dehydrated Manure: Finely pulverized cow manure, containing at least 60% organic matter, with a minimum analysis of 2-1-1.

b. Rotted Manure: Well rotted cow manure. Age shall be no less than 9 months and no more than 18 months. Containing no more than 40% straw or litter. Free from fresh manure, saw dust, wood chips, leather chips, tanbark, long straw, salt hay, stones, chemicals used to hasten decomposition, and other foreign and injurious substances.

E. Fertilizers: Deliver in standard size containers showing weight, guaranteed analysis, and name of manufacturer. Keep dry prior to use.

1. Planting Tablets: Tightly compressed, slow-release fertilizer tablet, analysis as recommended by Contractor's Soil Testing Laboratory.

2. Commercial Fertilizer: Types and formulations as recommended by soils testing laboratory.

3. Single Superphosphate (0-20-0): Granular.

4. Potassium Sulfate (0-0-52): Granular.

5. Iron Sulfate: Ferrous or ferric. Minimum 20% elemental iron.

6. Dolomite Lime: Raw, ground limestone containing not less than 85% of total carbonates. 60% of material passing No. 60 sieve, and 100% passing No. 20 sieve.

7. Calcium Carbonate Lime: Fine ground.

8. K-Mag: 0-0-22, with 18% magnesium.

9. Ammonium Sulfate: 21-0-0.

10. Agricultural Gypsum: Finely ground, even particle size.

11. Urea Formaldehyde: 38-0-0.

12. Bone Meal: Commercial raw, finely ground, with minimum 1% nitrogen and 20% phosphoric acid.

F. Mulch: Shredded hardwood bark of even consistency, intended for horticultural use and containing less than 2% non-bark wood particles.

G. Herbicides for Weed Control: Limited to those types of pre-emergent and post-emergent types listed and approved by State and Federal regulatory agencies. Make applications only under direct supervision or recommendations of person licensed or qualified by applicable State regulatory agencies.

2.05. DECIDUOUS SHRUBS

A. Form and Size: Deciduous shrubs with not less than the minimum number of canes required by and measured according to ANSI Z60.1 for type, shape, and height of shrub.

2.06. WEED-CONTROL BARRIERS

A. Polyethylene Sheeting: ASTM D 4397, black, 0.006-inch- minimum thickness.

2.07. PLANTER LINERS

A. Rubber membrane made from EPDM polymer formulated to be plant compatible, 0.045” minimum thickness.

1. Primer as manufactured by membrane manufacturer to clean and prepare planter liner for installation, application of splice adhesive.

2. Cover strip tape designed to cover and seal seams as approved by membrane manufacturer.

3. Bonding adhesive and splice adhesive as manufactured by plant liner membrane manufacturer.

4. Water block as recommended by membrane manufacturer for use at the termination edges of the planter liner to create a seal between the membrane edge and the substrate.

5. Aluminum termination bar to secure edge of membrane to substrate. Termination bar to be secured with fasteners of same material or stainless steel and of sufficient length to secure termination bar and membrane into substrate.

6. Sealant to continuously seal top edge of termination bar and edge of membrane to planter substrate.

B. Plant liner system shall be PondGuard as manufactured by Firestone Specialty Products or approved equal.

2.09. SOD

A. Number 1 quality premium complying with Turfgrass Producers Institute “Specifications for Turfgrass Sod Materials” in its “Guideline Specifications to Turfgrass Sodding”. Furnish viable sod of uniform density, color and texture, strongly rooted and capable of vigerous growth and development when planted. Species of sod to match existing or as indicated.

2.11. SOURCE QUALITY CONTROL

A. Material Analysis Testing and Recommendations: Perform soil tests and furnish recommendations as follows.

1. Tests for Site Soil and Import Soil:

a. Chemical Analysis: Soil fertility and agricultural suitability analyses, including nitrate nitrogen, ammonia nitrogen, phosphorus, potassium, calcium, magnesium, boron, pH, and electrical conductivity.
b. Physical Analysis: Particle sizes according to USDA classification. Include percentage by weight of organic content.

2. Soil Samples for Testing: Furnish to Contractor's Soil Testing Laboratory not less than 2 ft^3 each of proposed site soil and import soil. Soil samples shall be suitably packaged and sealed to prevent contamination.

3. Recommendations: Furnish written soil recommendations for the following.

   a. Soil for Planting Areas Not On Structure: Amending, plus initial and maintenance fertilization types and amounts.

PART 3 EXECUTION

3.01. 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.

3.02. PLANTING SEASON

A. General: Complete soil preparation work far enough in advance of optimum planting season to allow sufficient time for planting operations. Do work at such times as are recommended by university agricultural extension or are accepted horticultural practice under similar climatic conditions.

3.03. PLANT BED PREPARATION

A. Loosen subgrade of planting bed areas to a minimum depth of 6 inches (150 mm). Remove stones larger than 1-1/2 inches 38 mm in any dimension and sticks, roots, rubbish, and other extraneous materials.

B. After light rolling and natural settlement, spread planting soil mixture to depth required to meet thickness, grades, and elevations shown. Place approximately one-half the thickness of planting soil mixture required. Work into top of loosened subgrade to create a transition layer and then place remainder of planting soil mixture.

C. Planting soil shall be two parts pulverized top soil and one part course sand. The sand shall be added and mixed during the pulverization process only. Soil amendments can be mixed on site.

3.04. EXCAVATION FOR 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 Shrubs: Excavate approximately 1-1/2 times as wide as ball diameter and equal to ball depth, plus 3 inches of planting soil setting layer depth; maintaining 12” minimum clearance all around sides of rootball.

   2. Container-Grown Shrubs: Excavate to container width and depth, plus 3 inches of planting soil setting layer depth.

3. Dispose of subsoil removed from landscape excavations. Do not mix with planting soil or use as backfill.

4. Obstructions: Notify Authority if unexpected rock or obstructions detrimental to shrubs are encountered in excavations.

5. Fill excavations with water and allow to percolate out, before placing setting layer and positioning shrubs.

3.05. PLANTING 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 top 1/3 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 one-half 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. Set container-grown stock plumb and in center of pit or trench with top of ball raised above adjacent finish grades as indicated.

1. Carefully remove containers so as not to damage root balls.

2. Place stock on setting layer of compacted planting soil.

3. Place backfill around ball in layers, tamping to settle backfill and eliminate voids and air pockets. When pit is approximately one-half 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.

C. Set bare-root stock on cushion of planting soil. Spread roots without tangling or turning toward surface, and carefully work backfill around roots by hand. Puddle with water until backfill layers are completely saturated. Plumb before backfilling, and maintain plumb while working backfill around roots and placing layers above roots. Remove injured roots by cutting cleanly; do not break.

1. Set collar 1 inch (25 mm), below adjacent finish grades, unless otherwise indicated.

D. 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.

3.06. SHRUB PRUNING

A. Do not prune in first year unless to remove crossed or broken branches. Prune, thin, and shape shrubs according to horticultural practice and as directed by Authority.

B. Prune, thin, and shape shrubs according to standard horticultural practice. Prune shrubs to retain required height and spread. Unless otherwise directed by Authority, remove only injured or dead branches from flowering shrubs. Prune shrubs to retain natural character. Shrub sizes indicated are size after pruning.

3.07. MULCHING

A. Install weed-control barriers before mulching according to manufacturer’s written instructions. Completely cover area to be mulched, overlapping edges a minimum of 6 inches.

1. Material and Seam Treatment: Polyethylene sheeting with seams taped.

B. Mulch backfilled surfaces of pits, trenches, planted areas, and other areas indicated.

C. Organic Mulch: Apply 3 inches minimum thickness of organic mulch and finish level with adjacent finish grades. Do not place mulch against trunks or stems.

D. Mulch to fully cover landscaping area and allowing none of the weed barrier to be visible. Install mulch as recommended by manufacturer.

3.09. INSTALLING SOD

A. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.

B. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to subgrade or sod during installation. Tamp and roll lightly to ensure contact with subgrade, eliminate pockets and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.

1. Lay sod across angle of slopes exceeding 1:3.

C. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches below sod.

3.10. INSTALLING PLANTER LINER

A. Building foundation to be clean, dry and free of grease and oil. New concrete and mortar must be cured and dry. Remove all protrusions, sharp edges, dust, dirt and debris. Patch cracks and voids. Surfaces to receive liner to be smooth.

B. Deliver, handle and store planter liner materials as recommended by manufacturer to avoid damage to materials.

C. Temperature range for installation of planter liner system shall be as recommended by manufacturer. Do not install liner on frozen surfaces or when moisture is in the air. Do not handle membrane when it is cold and brittle.

D. Liner membrane material to be of sufficient size to avoid or minimize seams. Seams shall be bonded and sealed following manufacturer’s directions and utilizing primers, sealants and other materials manufactured or recommended by the manufacturer.

E. Install planter liner membrane as recommended by manufacturer. Bond membrane to substrate using manufacturer’s bonding adhesive as directed.

F. Provide and install water block, termination bar and sealant continuously at edges of planter liner membrane to create a watertight seal to the planter wall. Cut termination bar at corners and fasten one inch maximum from end of all sections. Secure termination bar directly to substrate with approved fasteners at specified spacings.

G. Take care to not puncture planter liner membrane while performing the installation work. Do not allow shavings from the metal termination bar or screws to fall into the planter and potentially damage the membrane.

3.12. FIELD QUALITY CONTROL

A. Supervision: Employ a qualified foreman continuously on site during the Work.

B. Plant Materials: Subject to review at place of growth and upon delivery at project site. For distant material, submit clear color photographs, with indication of scale, for preliminary review. Arrange procedure for review and tagging of plant material at time of submission of proposed nursery sources.

C. Observation of Work: Give at least 3 working days notice. Request observation at following stages.

1. During amending of soil and finish grading.
2. After plants are spotted, but before growing containers are removed or holes are dug.
3. During planting of shrubs.
4. During sodding operations.
5. When installation is completed, but before start of maintenance.

D. Final Acceptance: Perform at completion of plant maintenance period. Give written notice of request in advance.

1. Cleanup: Prior to final acceptance, repair plant basins, and clear area of debris. Leave Work in neat, orderly condition.

3.13. CLEANUP AND PROTECTION

A. During exterior planting, keep adjacent pavings and construction clean and work area in an orderly condition. Prior to final acceptance, clear area of debris.

B. Protect exterior plants from damage due to landscape operations, operations by other contractors and trades, and others.

3.14. DISPOSAL

A. Disposal: Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off the property.

3.15. LANDSCAPING MAINTENANCE

A. Maintenance Period: Maintain plants throughout planting operations. After observation at completion of planting, maintain work until date of final acceptance. Maintenance prior to date of final acceptance shall be without increase to the Contract Sum.

B. Procedure: Provide complete maintenance program, commencing at completion of plant material installation. Maintain plants in vigorous, healthy condition. Should occupancy of building by Authority occur before end of maintenance period, provide Authority with written description of work to be done. Arrange for specific time each week when maintenance functions will be carried out.

C. Fertilization Program: As recommended by Contractor's Soil Testing Laboratory.

D. Settling: If plant settles below finish grade, raise to proper level.

E. Replacement: Replace unhealthy, damaged, or dead plants and/or sod with material as specified.

F. Watering: Water newly installed sod as required during the maintenance period.

G. Mowing: Mow the newly installed sod as required during the maintenance period. Maintain height of grass at approximately one inch. Remove any weeds.

END OF SECTION

SECTION 33 68 00

SEWER SYSTEMS

PART 1 GENERAL

1.01. RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Special Conditions and Division 01 Specification sections, apply to this section.

1.02. SCOPE OF WORK

A. The Contractor shall furnish all labor, material, equipment, and services necessary for furnishing and installing sewer systems including, but not limited to, piping and connections; construction of catch basins, manholes, inlets and cleanouts; connections to existing and proposed sewers, catch basins, inlets and manholes; modifications to existing systems; connections to city sewers; excavation and filling; and testing; at the locations shown on the Drawings and/or as specified herein.

B. Work also includes mortar, bricks and grout; cleaning and removal of construction debris from within; furnishing and setting of frames and grates; connections, including cutting, coring and grouting to existing and proposed sewer lines and drains; and other appurtenant work required for execution of the sewer system.

1.03. RELATED WORK

A. Related work specified elsewhere includes:

1. Division 22 Plumbing, Section22 40 00 Plumbing.
2. Division 31Earthwork, Section 31 20 00 Earthwork.
3. Division 31 Earthwork, Section 31 20 10 Earthwork for Underground Utilities

1.04. SUBMITTALS

A. The Contractor shall furnish shop drawings, product data and samples as follows:

1. Product Data: Provide data indicating pipe, joints, fittings, structures and appurtenances.
2. Manufacturer's Installation Instructions: Indicate special procedures required to install Products specified.
3. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
4. Shop drawings for cleanout structures, riser pipe, reducers and roof drain connections; and connection to existing sewer structure.
5. Coordination drawings showing pipe sizes, locations, elevations and materials. Show manholes. Include profile drawings if required by the Authority.

1.05. REFERENCES

A. IDOT Standard Specifications for Road and Bridge Construction, Adopted April 1, 2016, Sections 550, 602 and 604.

B. ASTM A74: Cast Iron Soil Pipe & Fittings

ASTM C564: Rubber Gaskets for Cast Iron Soil Pipe & Fittings

C. ASTM D2922: Test methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

1.06. PROJECT/SITE CONDITIONS

A. Verify that field measurements and elevations are as indicated.

B. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities to the Authority.

C. Verify locations of all existing utilities, manholes, and other site conditions. Coordinate connections to and interruptions of existing utilities with the Authority and the respective utility company.

D.

1.07. RECORD DRAWINGS

A. Record location of pipe runs, connections, structures, and invert elevations.

PART 2 PRODUCTS

2.01. SEWER PIPE MATERIALS

A. Cast Iron Soil Pipe and fittings shall conform to ASTMA74.

2.02. PIPE ACCESSORIES

A. Fittings: Same material as pipe molded or formed to suit pipe size and end design, in required tee, bends, elbows, cleanouts, reducers, end sections and other configurations required.

2.03. STRUCTURES

A. Bricks for adjusting, if required, shall be common brick or high strength (certified) brick. Holes in high strength brick shall be filled with mortar. Concrete block will not be accepted.

2.04. BEDDING MATERIALS

A. Bedding: Clean course aggregate, gradation CA-11 conforming to Section 1004 of the IDOT Standard Specifications.

2.05. STORM-WATER INLETS AND DRAINS

2.06. BACKFILL

A. Trench Backfill: Clean Aggregate Conforming to Section 208 of the IDOT Standard Specifications.

B. Controlled Low Strength Material (C.L.S.M.) may be used as an alternative to Aggregate Backfill, See Section 31 23 00.

PART 3 EXECUTION

3.01. EXAMINATION

A. Verify that trench cut is ready to receive work and excavations, dimensions, and elevations are as indicated on Drawings. Trench to allow for minimum required cover for all piping.

B. The Contractor is to obtain and pay for all required permits and fees. The Contractor is required to arrange for and pay for all required permits and inspections of sewers and sewer structures by Chicago Department of Water Management or other governmental agency having jurisdiction. Provide copies of all permits and inspection approvals to the Authority.

3.02. BEDDING

A. Excavate pipe trench and hand trim excavation for accurate placement of pipe to elevations indicated. Correct over excavation with bedding material.

B. Place bedding material at trench bottom, level materials in continuous layer not exceeding 6 inch loose lifts compact to 95 percent of maximum dry density ASTM D1557.

C. Maintain optimum moisture content of bedding material to attain required compaction density.

3.03. PIPE

A. Install pipe, fittings, and accessories in accordance with Article 560 of the IDOT Standard Specifications and the manufacturer's instructions. Seal joints watertight.

B. Lay pipe to slope gradients shown on Drawings.

C. Maintain pipe foundations and trenches dry during progress of laying pipe. Plug partially completed sections to prevent entrance of water and debris until joints are sealed.

D. All dewatering should be performed as part of the sewer installation. The Contractor shall provide all retention systems to keep excavated area open for service installations and for maintaining safe working conditions.

E. Install piping at required slopes, not less than minimum required. Slope to be constant.

F. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's recommendations.

G. Install cleanouts where required or shown, including riser extensions to cleanouts. Install cleanout frames and covers in a cast-in-place concrete block flush with paving.

H. Pipe shall be laid so that it will not bear on the sockets. The socket end of the pipe shall be laid up-grade. No pipe shall be trimmed or clipped in order to fit in the socket. The face of the spigot shall be fully inserted into the socket.

I. Whenever pipe laying is discontinued, the unfinished end of the sewer shall be protected from displacement, cave-in, or other injury and a suitable stopper or dam shall be placed in the open end.

J.

3.05. SEWER CONNECTIONS

A. Where a storm sewer connection is to be made to a proposed storm sewer, a wye branch section of the proper diameter shall be installed in the receiving sewer at the junction.

B. Where a storm sewer connection is to be made to an existing sewer structure, at a location where no factory-made junction exists, a circular opening shall be made in the existing sewer structure of the same size as the external diameter of the proposed storm sewer connection, and a water tight flexible rubber collar shall be installed around the sewer pipe connection placed in the opening.

Sewer structure connections shall be made in locations as specified on the plans..
Make sewer service connections and down spout connections with service wyes of the same type of material as the parent sewer.

C. Any deficiencies found during the inspection process shall be corrected at the Contractor's expense.

3.06. ABANDON EXISTING

A. Where existing sewers or drain lines are scheduled or indicated on the drawings to be plugged, the Contractor shall plug same with concrete or brick and suitable mortar to the satisfaction of the Authority.

B. Contractor shall verify the sewer to be abandoned is not servicing other off-site properties prior to commencing abandoning procedures.

C. Where it is required to disconnect a sewer line form an existing sewer structure, the contractor shall reconstruct the structure wall using brick and mortar to the satisfaction of the Authority or their representative.

3.07. FIELD QUALITY CONTROL

A. Clean all sewers and structures prior to inspection and testing.

B. Request inspection by the Department of Water Management prior to and immediately after placing bedding.

C. Compaction testing shall be performed in accordance with ASTM D1557 or ASTM D2922.

D. All sewers and sewer structures shall be inspected by the Department of Water Management prior to the final payment to the Contractor.

E. If tests indicate Work does not meet specified requirements, remove Work, replace and retest at no cost to Authority.

F. Flows through existing sewers shall not be interrupted unless adequate provisions, approved by the Engineer, are made to continue service. If the Contractor causes any debris to enter the existing sewers, that entire section of sewer between manholes shall be thoroughly cleaned and rodded at no cost to the Authority.

G. Inspect piping for defects in materials or workmanship. Inspect piping for leaks, cracks, broken or crushed sections, deflection, or poor alignment. Inspect all joints and connections for leaks.

H. Replace any sections of piping damaged or leaking. Replace or repair any joints or connections that are leaking.

3.08. PROTECTION

A. Protect pipe and bedding from damage or displacement until backfilling operation is in progress.

END OF SECTION

SECTION 34 21 01
GENERAL REQUIREMENTS FOR TRACTION POWER EQUIPMENT

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and other specification sections apply to this section

1.02 SUMMARY

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. Traction power distribution cables and switches
8. Station batteries, battery chargers, distribution panel board for 125 volt dc control power and accessories
9. Telephone line sharing switches, Model M-394-B-01 (A-Star Electric).
10. Communication Cabinet
11. 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 overtemperature 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
33	Substation door alarm
33B	Breaker truck position switch
33R	Rectifier compartment door position switch
33T	Rectifier transformer equipment door position switch
37B	Battery low voltage alarm
43	Rectifier permissive control switch (REMOTE-LOCAL)
49T	Trans. winding over temp. device, first step
49TH	Trans. 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 charge 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. (ComEd Line 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. AC fault and under voltage detected by ac relays (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. Start and shut-down of each rectifier (Devices 201 and 294 for control and 4X for monitoring).

   d. Lockout shut-down of each rectifier (Device 286 for control and 4 for monitoring).

   e. DC feeder breakers (Device 172) (Devices 201 and 294 for control, and 201X and 172 for monitoring).

   f. 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 undervoltage, 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 over current 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).

i. 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

5. Conditional lockout of rectifier following 150 percent of rectifier full load current for approximately 2 hours (Device 49TH). 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 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.

12. 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.

13. Rectifier annunciators (Device 30) shall be of the back lighted window type Seekirk A1600 series or approved equal.

14. All terminal blocks shall be heavy duty Marathon series 1500, GE type EB-5 or approved equal.

15. 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.

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 sixty (60) 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 A of this section.

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. 15 kV AC Switchgear

b. Traction Power Rectifier Transformer

c. Anode Bus Duct

d. 600 Volt DC Silicon Rectifier

e. 800 Volt DC Switchgear

f. AC Test Cabinet

g. Vacuum Bottle Test Cabinet

h. 130 Volt DC Battery

i. Battery Charger

j. Battery Racks and DC Distribution Panels

k. Auxiliary Transformer, Automatic Transfer Switch and AC Panels

l. RTU and Communication Cabinets

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 sixty (60) 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:

      i. Internal wiring.
      ii. 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 color, the cable number, destination 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
Rectification Equipment in-line test	5	5
Transformer	5	5
Rectifier	5	3
AC Breakers	5	3
DC Breakers	5	3
Diode	5	5
Auxiliary Transformer	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 equipments 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 USED

PART 3 EXECUTION

3.01 TRACTION POWER REMOVAL SUMMARY OF WORK

A. Work required for this Section includes providing all labor, material, apparatus, equipment and services necessary to disconnect , remove, delivery, and storage of electrical and traction power items which are affected by or rendered obsolete by demolition work.

B. Removal of traction power equipment as detailed on the Plans at Broadway substation consists of, but not limited to, rectifier transformers, auxiliary power transformers, silicon rectifiers, ac switchgear assemblies, dc switchgear assemblies, anode bus ducts, negative equalizer bus, relays, getaway switches, getaway cables interconnection power and control cables connected between the traction power equipment, SCADA RTU’s and related appurtenances.

C. Items being removed which are salvageable and serviceable shall remain the property of the Authority and shall be stored by the Contractor in locations where directed by the CTA. Items of doubtful classification shall be reviewed with the Authority’s representative prior to disposal of same to determine their disposition. Care shall be exercised in the removal of these items to avoid damage.

D. Traction power equipment to be removed by contractor and retained by CTA includes but not limited to:

1. Rectifier unit #1 transformer, bus duct, rectifier, and DC circuit breaker.
2. Trackside disconnect switches and cabinets
3. Various relays, diodes, fuses, indicating meters, circuit breakers, etc. from AC and DC switchgear deemed useful by CTA maintenance department.
4. Batteries, racks, and charger.
5. Retained equipment to be dismantled and relocated by contractor to a CTA storage location designated by the CTA. Storage will be located in the Chicago area.

Contractor to provide all equipment and labor necessary to load, transport, unload, and place equipment into storage.

3.02 TRACTION POWER INSTALLATION SUMMARY OF WORK

A. Traction power installation includes providing all labor, material, apparatus, equipment and services necessary to design, manufacture, test, deliver, install and commission new equipment at Broadway substation as detailed in the Plans and summarized in the following:

1. 15kVAC switchgear assemblies

   a. Construct new 15 kV AC class switchgear consisting of 2 (two)-12.6 kV bus sections, incoming ComEd feeder breakers, metering cubicles, bus tie, auxiliary control power transformer cubicles, rectifier breakers, and control wiring as shown on the drawings.

2. 12.5kV ComEd lines

   a. Construct new ComEd service disconnect switch pads and connect new concrete encased duct lines from ComEd underground service lines to new ComEd service disconnect switches and then from ComEd disconnect switches to new CTA 12.6 kV incoming line breakers (via metering cubical).

   b. Contractor to coordinate new ComEd electric service line installation with new substation equipment installation.

3. Rectifier-transformer assemblies

   a. Install new underground conduit beneath floor slab in stages between 12.6 kV breaker cubical and new transformer, between new rectifier positive terminal and new DC breaker cubical, and new rectifier negative terminal and existing negative bus.

   b. Install new dielectric flooring below and around new rectifiers as shown on the drawings.

   c. Construct new 2.5 kW natural convection air cooled transformer/rectifier assemblies complete with anode bus duct and control wiring in stages where shown on the drawings

   d. Anode bus duct shall be free-standing, supported by the transformer and rectifier frames, and not depend on attachment to the substation building for support.

   e. Connect new rectifier transform primary to new 12.6 kV rectifier breakers via 15kV cable in underground conduit.

   f. Connect each rectifier positive terminal to new DC switchgear with 6-1500 kcmil cables. Connect each rectifier negative terminal to existing negative bus with 6-1500 kcmil cables as shown on the drawings.

4. 800 volt dc switchgear assemblies

   a. Construct new 800 volt DC switchgear consisting of rectifier cathode breakers, railway feeder breakers, auxiliary cubicles and control wiring as shown on the drawings.

b. Install new dielectric flooring below and around new DC switchgear as shown on the drawings.

5. Cable Tray

a. Install new fiberglass cable tray as shown on the drawings.

6. DC Feeder and communications cables

a. Feeder and communications cables shall be installed in stages and in a manner to minimize interference with train operations.

b. Install new overhead cable penetration openings in east substation wall.

c. Install new overhead DC cable racks from east wall cable openings to existing DC feeder cables as shown on the drawings.

d. Install new aerial cable bridge structure, getaway switches, and cable from substation to right of way as shown on the drawings.

e. Install new communications cable aerial supports as shown on the drawings.

f. Install new cable trough, potheads, cable racks, and cable from wayside switches and terminate to contact rails.

g. Install new negative cable from substation negative bus to wayside negative bus and wayside MH as shown on the drawings. Terminate to existing wayside negative bus and existing MH negative cables as shown on the drawings.

h. Break into existing cable vault below existing DC switchgear and temporally route new 1500 kcmil cables to existing DC feeder breakers (8 feeder sections) as shown on the drawings.

i. Connect new 1500 kcmil negative feeders to existing negative bus.

j. Install new overhead communications cable to wayside terminal box and terminate in existing substation communications cabinet.

k. After new DC switchgear installation, contractor to re-route newly installed feeder cables into new DC feeder breakers (top entry). Install new 1500 kcmil cable from ELF feeder to ELF trackside getaway switch.

7. Negative Bus

a. Existing negative bus will be re-used for connection to new equipment. Unused portions of negative bus will be retired in place.

8. Grounding

a. Install new 1/4"x2" copper ground bus as shown on the drawings.

b. Install new ground rods and ground wells where indicated on the drawings.

c. Install new bare copper underground/under-slab ground loops and cables where shown on the drawings.

d. For each new DC feeder cubical, install new surge arrestors and associated ground leads to station ground bus.

9. Foreign Utility Electrolysis Drains

    a. Remove out of service ATT electrolysis drain equipment

    b. Relocate existing ComEd electrolysis drain equipment as needed to install new DC surge arrestors.

10. For Station batteries, battery chargers, distribution panel board for 125 volt dc control power and accessories, SCADA, and other ancillary equipment related to traction power, see plans and specifications.

11. Note this summary may not have captured all work required for the complete system or all work shown on the drawings or required under this contract.

END OF SECTION

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
   c. Chief Rectifier Engineer
   d. Contracts Engineer
   e Substation Design Engineer
   f. DC Switchgear Engineer
   g AC Switchgear Engineer
   h. Transformer Engineer
   i. Battery equipment 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. AC& DC switchgear
      b. Anode bus duct
      c. Rectifier
      d. Transformer
      e. In-line
      f. 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 Electrical 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. <u>DETAILED LIST OF DISCUSSION POINTS:</u>

   1. <u>Transformer-Traction VPE Dry Type</u>

a. Certified dimensions and weight
b. No-Load losses
c. Outdoor vs. Indoor enclosure
   1.Outdoor vents
   2. Blowing snow protection
   3. Heaters
d. Location of bus duct and bus duct support, no external supports
e. Location of incoming primary cables, coordinate with drawings
f. Location of control cable entrance, coordinate with drawings
g. HV compartment and barrier
h. Access
i. Lifting and jacking points
j. Testing requirements

2. Transformer-Auxiliary Control Power

a. Certified dimensions and weight
b. Construction type
c. Size
d. Ventilation requirements.
e. Access
f. Disconnect means
g. Testing requirements

2. Anode Bus

a. Bus size, spacing, bracing, and configuration.
b. Dimensions and construction details, including weight.
c Duct supporting means-no external supports
d. Location with respect to transformer and rectifier. Minimum distance between transformer and rectifier shall be 6 feet.
e. Shipping split sections.
f. Location of insulated section of bus duct.
g. Heaters
h. Discuss testing as per specifications.

3. Rectifiers

a. Certified base dimensions, mounting details, clearance dimensions, and weight.
b. Location of negative cable entrance – top and bottom, coordinate with drawings
c. Location of positive cable entrance – top and bottom, coordinate with drawings
d. Location and detail of anode bus takeoff and supporting means-no external supports
e. Location of control cable entrance, coordinate with drawings
f. Location of control (and negative disconnect switch) equipment. Need physical barrier between control and power sections.
g. Location of ground fault relay for ground connection. Ground detector must function without damage up to 800 volts above ground.
h. Details of rectifier cooling configuration.
i. Details of surge protection circuitry.
j. Details of diode current balancing circuitry.
k. Number of diode legs per phase.
l. Review of coordination curve.
m. Review data and calculations required under Specifications.

n. Details of recommended handling procedure.
o. Details and arrangement of floor insulation system, levelness, flatness and anchoring system.
p. Thickness of floor insulation to be considered in developing the dimensions of bus duct.
q. Detail for removal and replacement of diodes for maintenance.
r. Cable supports for 1500 MCM cables.
s. All rectifiers have specified number of annunciator targets.
t. Details of construction of rectifier.
u. Interchangeability of diodes, fuses, interconnecting links without affecting current balance.
v. Diode assembly keying to prevent interchange of incorrect assemblies.
w. How is correct diode clamping established to insure against uneven pressure on diode relative to heat sink.
x. Discuss type and arrangement of diode heat sink thermal devices.
y. Matched diodes not acceptable for satisfying current balance requirements.
z. Rectifier assemblies shall include hinged doors with rubber gasketed safety glass panes or equivalent and all sections.
aa. Identify the rectifier 89N switch contractor proposes to use.
bb Discuss snubber circuit.

4. <u>AC Switchgear</u>

a. Certified base dimensions, mounting details, clearance dimensions and weight.
b. Location and dimensions of power cable entrance, coordinate with drawings
c. Location and dimensions of control cable entrance, coordinate with drawings
d. Location and detail of ground connections.
e. Location for dc control power connections.
f. Detail of auxiliary transformer compartment.
g. Detail of line metering compartment.
h. Shipping section splits.
i. Detail of test cabinet.
j. Standard control schematic.
k. Detail of bus tie compartment.
l. Discuss detail of ComEd delivery of metering current and potential transformers.
m. Discuss details of SEL relays and relaying scheme.
n. Discuss details of auto-transfer scheme.
o. Discuss anchoring method
p. Discuss ComEd requirements

5. <u>DC Switchgear</u>

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 operatioin.

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 KCM 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

6. Battery, Chargers, and Racks

a. Establish size for each substation.
b. Battery rack - 2 step
c. Battery type and construction

7. 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 03
TRACTION POWER RECTIFIER TRANSFORMER

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Special Conditions, Division 01 Specification sections and Section 34 21 01 General Requirements for Traction Power Equipment, apply to this section.

1.02 SUMMARY

A. This section covers the requirements for designing, manufacturing, testing, delivering, installing and commissioning the Rectifier Transformers for Traction Power Substations.

B. The rectifier transformers shall be vacuum pressure encapsulated (VPE), ventilated, self cooled, dry type for indoor or outdoor use.

C. Related Sections:

1. Section 34 21 01, General Requirements for Traction Power Equipment
2. Section 34 21 04, Traction Power 600 volt DC Silicon Rectifier
3. Section 34 21 06, Traction Power Anode Bus Duct
4. Section 34 21 09, Traction Power Support
5. Section 34 21 11, Traction Power Equipment Testing

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 TECHNICAL REQUIREMENTS

A. The design of each rectifier transformer shall be such as to fully coordinate with and operate in conjunction with the specific rectifier furnished under Section 34 21 04, 600 Volt DC Silicon Rectifier. Each transformer shall have electrical and mechanical characteristics and general design features as follows:

B. Electrical Characteristics:

1. KVA Rating:

    a. Rating commensurate with rectifiers, detailed under Section 34 21 04.

    b. Average winding temperature rise by resistance at a 40 degrees Celsius ambient shall not exceed 80 degrees Celsius after a 2 hour, 162 percent RMS load following continuous 100 percent load stabilized thermal conditions.

    c. Average winding temperature rise by resistance at a 40 degrees Celsius ambient shall not exceed 85 degrees Celsius after temperature stabilizes at 150 percent full load current.

    d. Maximum winding hot-spot temperature rise shall not exceed 180 degrees Celsius in an ambient corrected to 40 degrees Celsius after running at 300 percent full load current for 36 minutes following stable thermal conditions at 100 percent full load current.

    e. Winding insulation shall be Class H for a total temperature of 220°C or better.

2. Windings:

    a. All windings and connections shall be delta or wye connected copper.

    b. High voltage winding to be for 3-phase, 60 Hz, 12,600 volt ac nominal.

    c. Transformer shall have a 3-phase low voltage copper windings delta connected, arranged in accordance with ANSI circuit NO. 25 or 26, as defined in IEEE Standard 1653.2 to provide 6-phase, double-way supply to the rectifier. Voltage and related characteristics shall commensurate with rectifiers detailed in IEEE Standard 1653.2

    d. All current carrying conductors and connections shall be insulated.

3. Taps:

    a. The rectifier transformer shall be provided with no-load, full capacity 3 plus 2 1/2 percent and 2 minus 2 1/2 percent high voltage windings taps, complete with necessary manual tap changer mechanism. The rectifier transformer tap voltage ratings shall be:

13,545 Volts	12,600 Volts
13,230 Volts	12,285 Volts
12,915 Volts	11,970 Volts

    b. The no-load taps shall be brought to an externally operated manually taps changer for operation only when the transformer is de-energized. The taps shall be accessible through removable panels on the transformer enclosure.

    c. No-Load Losses

        i. No-load losses for 3,000 kW rectifier transformer at rated voltage shall not exceed 6,000 watts.
        ii. No load losses for 2,500 kW rectifier transformer at rated voltage shall not exceed 5,100 watts.

    d. Impedance and Insulation Voltage Class:

i. Impedance shall be as low as possible consistent with good design. Exact value shall be determined by the guaranteed no load losses and by the requirements for output voltage.
ii. High Voltage insulation class shall be 15 kV with BIL of 110 kV or more. Low voltage insulation class shall be 1.2 kV with BIL of 45 kV or more.
iii. Stand off insulators and bushings for all terminals shall be glastic.

e. H.V. Entrance Compartment for rectifier transformers):

i. The high voltage entrance compartment shall make provisions for the bottom entry and heat shrink terminations similar to Raychem HVT-G/SG termination of the incoming high voltage 15 kV shielded, 3-1/c-2/0 AWG non-metallic jacketed, copper conductor cable from 15 kV ac feeder breaker.
ii. The H.V. entrance compartment for rectifier transformer shall include the necessary conduit termination, fittings, cable supports, and connections to the transformer studs. This Contractor shall provide cable terminators (described in Section 34 21 65, Basic Electrical Materials and Methods), suitable insulating material and tape to properly insulate, for 15 kV service, all exposed current carrying members of terminator and transformer studs. Provision for mounting terminals shall be provided in the compartment. Terminator grounding lugs shall be provided for grounding to the transformer ground pads.
iii. The compartment shall be physically enclosed and separated from all other areas of this transformer.

f. L.V. Entrance Compartment:

i. The low voltage entrance compartment shall provide for bolted connection through a flexible connection to the anode bus furnished under Section 34 21 06. Internal bracings inside the compartment shall be provided to support the anode bus duct.

g. Noise Level:

i. Noise level shall not exceed the decibels (A) level noted in IEEE Standard C 57.12.01.

C. Mechanical Characteristics:

1. The transformers shall be so designed that all connections, tap changing devices, meters, relays and probes are easily accessible for inspection and maintenance. All devices such as fuses, switches, terminal blocks, etc. shall be mounted within 18 inches of the face of the cubicle.

2. The enclosure shall be rodent proof with solid bottom and shall be substantial enough to prevent physical damage to the transformer coils Transformers shall be provided with vent screens and closed bottom to prevent rodents from entering.

3. Outdoor enclosures shall be corrosion resistant and protect the transformer coils, connections, and ancillary equipment from wind driven rain and snow.

4. The enclosure shall be provided with an interlock system such that the transformer will not be energized when any portion of the enclosure is open. This interlock system shall be of the type that is not affected by vibration, wind or other occurrences which

would cause false operations. The security of the enclosure shall be monitored by a light on the front of the enclosure.

5. The enclosure shall be constructed of panels which are hinged so that panel may be opened in a horizontal direction. Each panel shall have a three-point latching mechanism operated by a pad lockable handle.

6. Vacuum Pressure Encapsulated VPE construction:

   a. The completed coil winding (HV and LV) shall be dried at atmospheric pressure in an oven through which hot air is continuously circulated. After the coil is preheated and dried, it shall be vacuum impregnated in silicone or polyester resin. The resin shall be cured on the coil following an established temperature vs. time baking cycle in a hot air circulating oven. After the resin is cured on the coil, a second coating of silicone or polyester varnish shall be applied to the impregnated coil and cured as above. The resin shall completely encapsulate the coils and thus sealing against moisture, dirt, and other extraneous contaminates.

   b. The transformer core shall be constructed of high grade non-aging silicon steel laminations with high magnetic permeability and low hystersis and eddy current losses. Magnetic flux densities shall be kept well below the saturation point. The core shall be a step lap mitred design and clamped together with heavy steel members.

7. There shall be no rigid mechanical connections tying the low voltage (LV) and high voltage (HV) coils together. The HV and LV coils shall be supported and spaced apart by epoxy bottom support blocks, epoxy space blocks and shock absorbing top epoxy blocks to facilitate thermal expansion and contraction of the coils.

8. The coils shall be suitable for operation in an ambient temperature range of -50 degrees Celsius to +50 degrees Celsius without degradation or cracking of the insulation system. Electric strip heaters shall be included and sized to prevent moisture build up during periods of low transformer loading.

9. The coils must not absorb moisture and shall be suitable for operation at 50 degrees C ambient temperature at 100 percent humidity. The transformers must be suitable for prolonged storage in 100 percent humidity and be capable of immediately being switched on a full voltage and load without pre-drying.

10. The coils shall be fabricated in a facility with at least 5 years experience in the manufacture of transformer coils for the use on Rapid Transit Systems. The manufacturer of the coils shall also submit factory certified tests showing that prototype coils, rated 500 KVA (minimum) have been subjected to temperature shock tests whereby the coils have undergone temperature changes of 100 degrees Celsius (minimum) in a 5 minute (maximum) time period either by heating a cold transformer or cooling a hot transformer - followed by a 110KV BIL test. Following this test, the transformers shall have been examined for cracking by both visual testing and corona discharge testing. In the absence of such certified test, the Contractor shall arrange for factory witness testing of this type of shock testing. No VPE coil transformer design will be accepted without such certified or witness tests.

11. Windings:

   a. The transformer coils should be of round concentric construction. The windings shall be wound without joints to provide minimum voltage stress on insulation.

b. Low voltage coils wound with continuous copper strip or of a helical construction. High voltage coils shall be of barrel wound or of continuous disc construction. No splices will be allowed. Insulation system shall be based upon the voltage rating, temperature rating and the compatibility of the insulation with epoxy resin. This includes all appurtenant materials such as ties, mounting pads, etc.

12. Core and Coil Assembly:

a. The individual coils shall be assembled on the core so that an even compression on the coils is maintained through the warming/cooling cycles.

13. The entire assembly shall be braced or bolted adequately to prevent displacement and distortion under all normal conditions of handling and operation under short-circuit conditions. Locking provision shall be made for all inside bolted members or connections. Serial number shall be stamped on core or core clamp in a conspicuous place.

14. Tap changer shall be arranged for one person using simple hand tools. All energized parts shall be adequately insulated. The tap arrangement shall be designed to prevent incorrect tap connections. Actual arrangement requires approval of the Authority.

15. Base:

a. The transformer shall be mounted on skids of the I-beam, sled-runner type, or approved equal. Base members shall be suitable for skidding in any direction on rails or rollers. Jack pads and crane lifting lugs shall be provided. The base drawings shall clearly indicate the type of jack pads, their outline dimensions and their location from the longitudinal and transverse axes of the transformer, and also the dimensions and location of the base members so as to facilitate design, by others, of the concrete foundation.

16. Two (2) stainless steel transformer grounding pads shall be provided.

17. All metal work shall be thoroughly cleaned, treated against rust and corrosion, primed, bonderized and finished with two (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 transformer.

D. Protective and Maintenance Devices:

1. The rectifier transformer shall be provided with the following protective and maintenance devices:

a. Two-step winding temperature indicator with contacts which close on rising temperature for transformer alarm indication and tripping. A thermocouple shall be installed in the low voltage center winding to monitor the winding hot spot.

b. Door interlocks as specified.

c. Secondary and control wiring shall be ICEA Standard Type SIS, No. 12 AWG or larger, insulated for 600 volt ac service and shall be factory-wired to screw type terminal blocks for bottom or top connection to external conductors. Terminal blocks shall be General Electric Company, Type EB-5, Marathon Series 1500, or approved equal. Secondary and control wiring shall be in corrosion resistant conduit. Short flexible connections to devices shall be Sealtite flexible conduit, or approved equal.

d. Push to test indicating blue light shall be installed on the transformer enclosure to mounted doors condition. Blue light "on" where any one transformer enclosures door is open. A nameplate shall be installed above the blue light. Electric strip heaters to prevent condensation when transformer is de-energized. Strip heaters to be supplied from external 120 volt (AC and/or DC) source.

e. Electric strip heaters to prevent condensation when transformer is de-energized. Strip heaters to be supplied from external 120 volt (AC and/or DC) source.

f. Nameplates showing winding connections, voltages, ratings, impedance, serial number, and other information as may be required, in accordance with latest edition of ANSI C 57.12.00.

g. Warning signs as required by NFPA-70E, Article 420 at the appropriate location.

2.02 DETAIL EQUIPMENT

A. The rectifier transformers shall be furnished with winding connections as listed below:

1. Items 1 and 3: Indoor dry type VPE coil construction rectifier transformer complete with all accessories. The transformer winding connections shall be 12,600V wye primary with secondary winding delta connected, suitable for operation with a 2,500 KW, 6 phase rectifier, as per IEEE Standard 1653.2, rectifier circuit number 26.

2. Item 2: Indoor dry type VPE coil construction rectifier transformer complete with all accessories. The transformer winding connections shall be 12,600V delta primary with secondary winding delta connected, suitable for operation with a 2,500 KW, 6 phase double way rectifier, as per IEEE Standard 1653.2, rectifier circuit number - 25.

2.03 QUANTITY OF EQUIPMENT REQUIRED

A. At Broadway Substation:

1. Item 1: One (1) VPE coil construction rectifier transformer ANSI circuit number- 26, complete with all accessories as described in Paragraph 2.02A.1 of this Section. The transformer shall be tagged: per CTA Standard STP-88

2. Item 2: One (1 VPE coil construction rectifier transformer ANSI circuit number 25, complete with all accessories as described in Paragraph 2.02A.2 of this Section. The transformer shall be tagged: per CTA Standard STP-88

3. Item 3: One (1) VPE coil construction rectifier transformer ANSI circuit number- 26, complete with all accessories as described in Paragraph 2.02A.1 of this Section. The transformer shall be tagged per CTA Standard STP-88.

2.04 DESIGN CALCULATIONS

A. The Contractor shall submit at design conference design calculations which shall include, but not be limited to the following:

1. Voltage Regulation Curve

2. Temperature Rise Curve

3. Power Loss Curve
4. Efficiency - Load Curve
5. Resistance
6. Impedance
7. X/R Ratio

PART 3 EXECUTION

3.01 INSTALLATION

A. See Section 34 21 01, General Requirements for Traction Power Equipment, for the rectifier transformer installation requirements.

3.02 TESTING

A. See Section 34 21 11, Traction Power Equipment Testing, for the rectifier transformer testing requirements.

3.03 SUPPORT EQUIPMENT

A. See Section 34 21 09, Traction Power Support, for rectifier transformer support equipment requirements.

END OF SECTION

SECTION 34 21 04
TRACTION POWER 600 VOLT DC SILICON RECTIFIER

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Special Conditions and Division 01 Specification sections, apply to this section.

1.02 SUMMARY

A. This section covers the requirements for designing, manufacturing, testing, delivering, installing and commissioning indoor metal clad 600 volt dc silicon rectifier assemblies for substations.

B. The rectifiers will be supplied directly from the new or relocated rectifier transformers covered in Section 34 21 03, Traction Power Rectifier Transformer, and will serve as the source of supply for the dc switchgear covered in Section 34 21 05, Traction Power 800 Volt DC Switchgear. Rectifier circuits shall be IEEE 1653.2 Latest Issue, circuit 25 or 26.

C. 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 03, Traction Power Rectifier Transformer.
3. Section 34 21 05, Traction Power 800 Volt DC Switchgear.
4. Section 34 21 06, Traction Power Anode Bus Duct.
5. Section 34 21 09, Traction Power Support.
6. Section 34 21 10, Traction Power Equipment Installation.
7. Section 34 21 11, Traction Power Equipment Testing.
8. Section 34 21 12, Traction Power In-Line Test on Rectification Equipment and Surge and Destructive Test on Diodes.

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

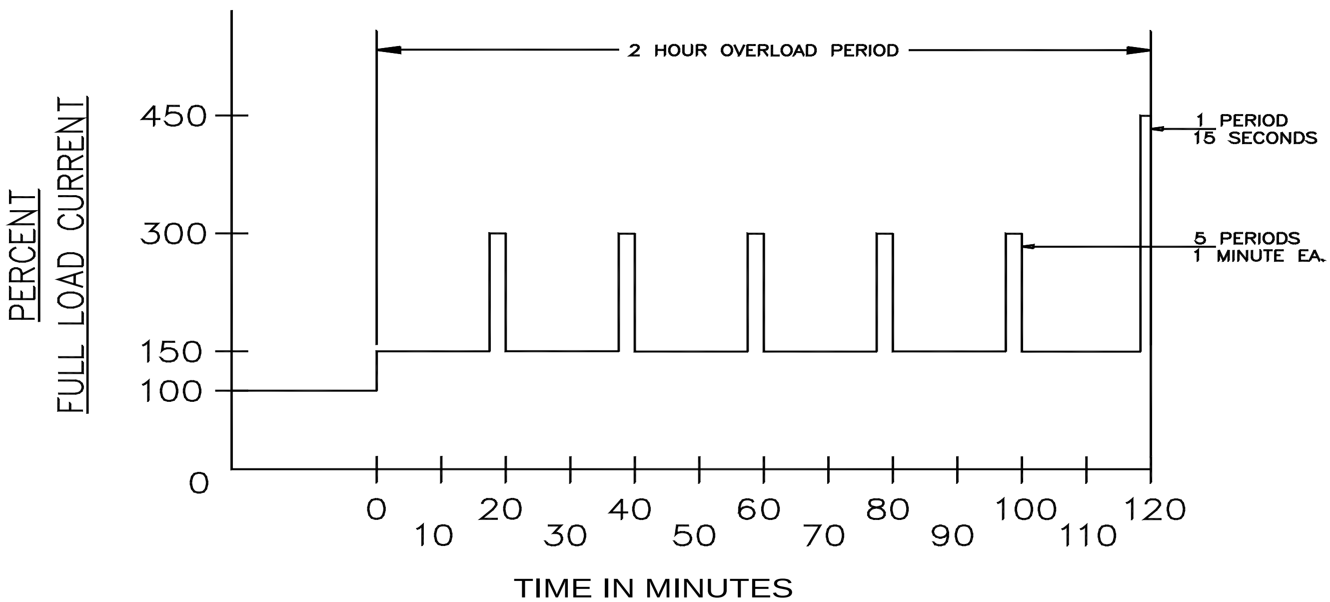
A. Deliver and store materials in manufacturer’s original packaging. Store materials in climate controlled and protected dry locations off ground in accordance with manufacturer’s instructions. Follow handling procedures approved by the manufacturer.

PART 2 PRODUCTS

2.01 TECHNICAL REQUIREMENTS

A. The rectifiers, using outside air under ambient conditions, shall be designed for parallel, non-attended operation as set forth under Paragraph 1.3B of Section 34 21 01, General Requirements for Traction Power Equipment, and shall function as integrated units with associated transformers and switchgear.

B. Each complete rectification package (including rectifier transformer, rectifier and anode bus) shall have a continuous full load output rating of 2500 kW at 600 volt dc at a maximum ambient-room temperature for 40 degrees Celsius (104°F). After constant temperature rise is reached following continuous full load, they shall be capable of operating guaranteed overload equal to base overload of 150 percent full load current for 2 hours and superimposed cycle overload consisting of 5 periods of 300 percent full load current for 1 minute, followed by 1 period of 450 percent full load current for 15 seconds, spaced throughout the 2 hour period as follows:



C. Each complete rectifier package (including rectifier, transformer and anode bus) shall have a full load overall efficiency of not less than 97.5 percent, a displacement power factor above 90 percent lagging and a regulation or voltage characteristic based on 500 MVA ac supply capacity and X/R ratio of 15 such as to provide output voltage within the limits set forth below when ac system voltage at no load corresponds to transformer tap voltage. These limits shall be met on all transformer taps. All dc values shall be based on use of averaging type meters.

Output Current	Output Voltage-DC
0.5 percent Full Load	641 to 636
100 percent Full Load	610 to 600
150 percent Full Load	594 to 582
300 percent Full Load	545 to 529
450 percent Full Load	500 to 475

D. Each complete rectifier package (including rectifier transformer, rectifier and anode bus and ac and dc switchgear) shall be capable of withstanding a bolted short circuit on the rectifier output terminals without damage to any component, including protective fuses and rectifier elements immediately following the 2 hour overload period specified in paragraph 2.01B above.

E. The rectifiers shall be designed so that damage to the rectifier elements and fuses is prevented by current-time overload relays. Thermal devices on heat-sinks shall take rectifier out of service and prevent rectifier operation under any combination of excessive ambient temperature, reduced heat sink efficiency and/or excessive base load such that the rectifier elements and fuses are no longer afforded complete protection by the current time overload relays. Each thermal device shall be mounted and wired to the terminal blocks to permit easy removal.

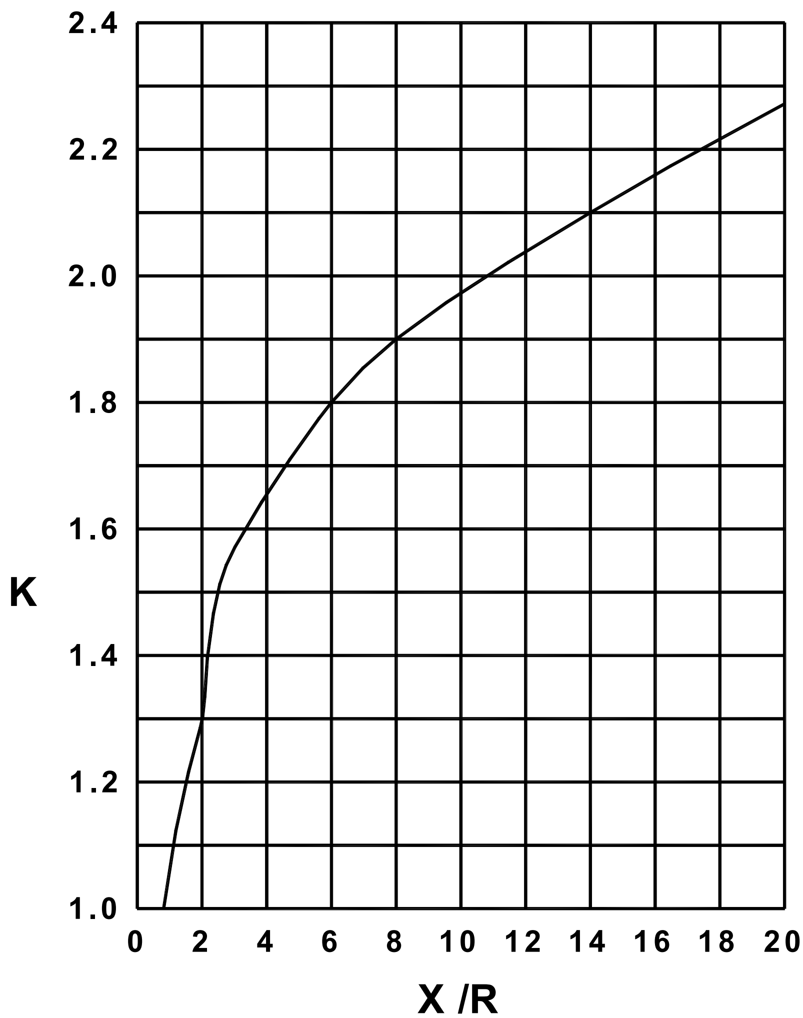
F. The manufacturer shall provide a sufficient number of diodes per phase, polarity to fulfill all the requirements of this Specification but in no case shall the number of diodes provided per phase polarity be less than the number "D" determined by the following calculations:

Let D =	Minimum quantity of diodes per phase leg.
Let C=	Published diode peak surge current rating in amperes (maximum peak value of rated non-recurrent one cycle sinusoidal current on a 60 Hz basis). Must conform with ANSI/EIA Standards for Silicon Rectifier Diodes and Stacks, ANSI/EIA-282A-1989.
Let X/R =	Overall reactance-to-resistance ratio, including alternating current supply system, transformer, bus duct, and rectifier.
Let K =	Transient RMS factor from figure below at the system X/R
Let Es =	Rectifier transformer low voltage winding voltage, line-to-line, at no load
Let Iss =	Average dc sustained short circuit current with rectifier output terminals bolted, with 500 MVA supply system at 12.6 kV, and

$$Z = \sqrt{R^2 + X^2} \text{ and Iss } = \frac{1.35(Es)}{(\sqrt{3})(Z)}$$

$$Then D = \left[\frac{0.74(Iss) + \left(\frac{C}{\sqrt{2}}\right)\left(\frac{1}{K}\right)}{\left(\frac{C}{\sqrt{2}}\right)\left(\frac{1}{K}\right) - 0.0074(Iss)} \right] + 1$$

TRANSIENT RMS FACTOR K AS RELATED TO THE SYSTEM X/R RATIO



Derived from AIE conference paper of May 17, 1961, "Short Circuit Currents on Power Rectifier Systems", Johannes Schaefer, Sipplington/Bodensee Germany.

G. Rectifier assemblies shall include interchangeable diodes, fuses, and interconnecting links throughout the rectifier section to permit interchangeability without affecting current balance compliance.

H. Each rectifier assembly shall include one section containing the devices required for control and supervision as set forth herein or shown on Contract Drawings. Normal control equipment and circuits shall be physically accessible, and so connected as to permit convenient testing and/or maintenance of relays and control circuitry. All devices such as fuses, switches, terminal blocks etc. shall be mounted within 18 inches of the front of the cubicle.

I. The rectifier assemblies shall be of the indoor, freestanding, metal enclosed type with hinged doors having rubber gasketed transparent safety glass panes, on the rectifier section and hinged doors on the auxiliary and/or control sections. Provisions shall be made to prevent energizing the rectifier while any door on rectifier section is open. All doors shall be securely fastened in the closed position with a minimum of three latches and easily opened without the use of tools. The rectifiers shall have jacking and lifting pads. All doors shall have edge stripping and be lockable with a padlock.

J. The 1500 kcmil solderless removable type terminal lugs shall be provided for each of 6 outgoing positive cables, and each of 6 outgoing negative cables. The solderless type lugs shall be Penn Union type V V L or approved equal. The cable supports shall be provided so that cables within the rectifier cubicle are self-supporting. The positive and negative power circuit cables shall enter from the bottom, unless specified otherwise.

K. The rectifier assemblies shall have an air filled chamber and shall be arranged for bolted connection to the anode buses furnished under Section 34 21 06, Anode Bus Duct, of this Specification. Sturdy supports shall be provided inside the rectifier assembly so that the anode bus is self-supporting. The anode bus will be connected to the low voltage terminals of the rectifier transformer. The flexible bus braids shall be used for connecting the anode bus. . Rectifier internal bus shall be copper with all bolted contact surfaces silver-plated or aluminum with all joints welded. The contact surfaces at cable take-offs and anode bus connections shall comply with Paragraph 1.03F, Section 34 21 01, General Requirements for Traction Power Equipment. Bolted joints in certain current carrying aluminum sub-assemblies within the rectifier may be permitted if, in the opinion of the Authority, such arrangement is advantageous to the Authority. In these cases, the contact surfaces of the aluminum/aluminum joints shall be nickel plated.

L. The secondary control and supervisory control wiring shall be ICEA Standard Type SIS No. 12 AWG or larger stranded switchboard wire. For circuits 600 volt and above, use XLPO wire insulated for 2000 volt dc service, similar to BOSTRAIL AAR S501 car wire, 2kV, extra flexible, XLPO insulation, soft annealed copper stranded conductor, as manufactured by DRAKA USA or approved equal. Cables shall be factory wired to screw-typed terminal blocks for connection to external conductors. The terminal blocks shall be General Electric Company Type EB-5, Weidemuller type SAK, Marathon Series 1500 or approved equal.

M. The floor area for installation of rectifiers shall be prepared from plastic resin cement Amazite or approved equal, 3/8" thick, to insulate rectifier structure from building structure, identical to the floor under dc switchgear. The rectifiers shall be secured to the insulated epoxy floor with approved insulated anchors. The plastic resin floor area shall extend three feet past rectifier on all sides, unless drawings indicate otherwise.

N. All metal work shall be thoroughly cleaned, treated against rust and corrosion, primed, bonderized and finished with two (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 with each assembly.

2.02 DETAIL EQUIPMENT

A. The equipment to be furnished shall be for use in the coordinated system shown on the Contract Drawings and shall be in accordance with the following:

1. 2,500 kW, 600 volt dc silicon rectifier indoor unit with ANSI standard circuit number 25 shall be furnished and delivered to the Substation sites as specified in Paragraph 2.03 of this Section.

2. 2,500 kW, 600 volt dc silicon rectifier indoor unit with ANSI standard circuit number 26 shall be furnished and delivered to the Substation sites, as specified in Paragraph 2.03 of this Section.

3. Each 600 volt dc indoor, self-cooled metal enclosed silicon rectifier unit shall be incorporated into one continuous enclosure and mounted on the insulated floor anchored by means of insulated bolts and made up of components including, but not limited to the following:

    a. One (1) set of current limiting fuses in the connections to each silicon diode which will protect all remaining diodes in the event of any diode failure, complete with one (1) diode fuse monitor. Fuse monitoring system shall consist of target type fuses which are clearly visible. Opening of one fuse in each phase polarity shall not reduce capacity from that listed in Paragraph 2.01B of this Section nor adversely affect ability to withstand short circuit.

    b. One (1) 2-stage diode fuse monitor. Diode fuse monitor shall sense an open (failed) diode fuse(s) and display location of failed fuse(s). An open fuse shall be considered the result of a diode failure. The first stage shall be any failed fuse on any rectifier circuit element (phase) and shall send an alarm to the rectifier annunciator (device 30). The fuse monitor second stage shall occur when a second fuse operates on any one rectifier circuit element and shall lockout the rectifier and also signal the rectifier annunciator of the second stage operation.

    c. Each individual silicon diode shall be hermetically sealed and mounted on adequate air-cooled heat sink for maximum heat dissipation. Twelve (12) circuit opening on rising temperature, bimetallic thermal devices shall be furnished and mounted on diode heat sinks and shall be connected as follows:

        i. Three (3) thermal devices shall be connected to provide rectifier positive first step high temperature alarm (the contacts wired to relay 26D1 located in the auxiliary control cubicle).
        ii. Three (3) thermal devices shall be connected to provide rectifier negative first step high temperature alarm (the contacts wired to relay 26D1A located in the auxiliary control cubicle).
        iii. Three (3) thermal devices shall be connected to provide rectifier positive second step high temperature trip (the contacts shall be wired to relay 26D located in the auxiliary control cubicle).
        iv. Three (3) thermal devices shall be connected to provide rectifier negative second step high temperature trip (the contacts shall be wired to relay 26DA located in the auxiliary control cubicle).

    d. Provide means to maintain current balance between diodes in each phase polarity and hold individual diode currents within guaranteed capability under all load conditions up to and including 450 percent full load current with one fuse per phase polarity open. Unless they are completely interchangeable, the reactors or other devices shall be keyed or otherwise mechanically matched to insure that they are always inserted in the proper location. With any diode fuse open at any and all rated loads, the current in any other diode in the same phase polarity shall not exceed its pro rata share by an amount greater than 20 percent. The pro rata share is defined as the total rated phase polarity current divided by the number of paralleled diodes in service in that phase polarity. The use of matched diodes will not be acceptable for this purpose. The diodes shall have a minimum repetitive peak inverse rating of 1800 volt. Each individual silicon diode shall be hermetically sealed and mounted on adequate air cooled heat sink for maximum heat dissipation.

e. Each rectifier shall be able to withstand a transient surge voltage of 3000 volt crest and 1.5 X 40 microsecond full wave shape of either polarity applied to all rectifier terminals, including cathode terminal while operating at rated current and full rated temperature. Surge diverter micro switches shall be wired to an auxiliary relay (Device 99Y) and indicating light, to indicate the failure to surge diverter devices.

f. One (1) set of the interlock switches (Device 33) designed to de-energize the rectifier when the rectifier access door(s) are opened exposing "Live" parts. The interlock contacts shall be wired in series to trip device 86. The switches shall be of the type which would keep the door open in the by-pass position without tripping device 86. This procedure is to be accomplished by turning the rectifier off first, then placing the switch in by-pass position, and after the rectifier door is opened; the rectifier should be able to be energized without tripping. The by-pass position will only be used during maintenance testing.

g. One (1) manual negative lead disconnecting switch (Device 89N), single pole, 800 volt dc, 8000 ampere. The switch shall be operable by an insulated handle and mounted inside the rectifier enclosure. The switch shall be Pringle Electric Mfg. Co., Filnor Inc., or approved equal.

h. One (1) auxiliary control compartment isolated from primary portion of the rectifier by suitable barrier, including:

   i. One (1) local control switch (CLOSE right TRIP left), (Device 1).
   ii. One (1) master control relay, (Device 4).
   iii. One (1) auxiliary master control relay, (Device 4x).
   iv. One (1) lockout relay with hand reset, (Device 86).
   v. One (1) conditional lockout relay, (Device 86X).
   vi. One (1) push to test white indicating light for device 86 integrity monitoring.
   vii. One (1) permissive control switch (REMOTE-LOCAL with REMOTE position at 12 o'clock and LOCAL clockwise), (Device 43).
   viii. One (1) incomplete sequence relay, (Device48).

i. One (1) set hot structure/ground detection equipment, including adjustable relays, associated devices and semi-conductor rectifier type auxiliary dc power supply (copper oxide not acceptable) to furnish continuous supervision of insulation of rectifier enclosure from the station ground and rectifier components. A positive potential of 75 volts on the rectifier enclosure shall cause lockout and de-energization of the rectifier (Device 64C). Loss of insulation to ground shall give a visual and audible alarm (Device 64X). Ground detection equipment must function without damage on structure potential up to 800 volt above ground potential. The alarm voltage and sensitivity shall be adjustable. Manual reset mechanical lockout is required for Device 64C. The relay shall be Swartz type, Model No. 2841-438 or approved equal.

j. One (1) set of dc voltmeter 0-800 volt dc scale.

k. One (1) annunciator with minimum of 22 points and an audible alarm. (Device 30) shall be as follows:

   i. An annunciator control (Device 30) consisting of 22 points shall be provided in the compartment at each rectifier to monitor various rectification unit alarms. It must be capable of operating and displaying all 22 alarms simultaneously. Separate terminal blocks shall be provided within the rectifier enclosure to accommodate all wiring from the incoming alarms.

ii. The annunciator shall be solid state, panel mounted, and rear wired. Each module shall be equipped with cards, terminals and bus wiring for two annunciator points per module. The annunciator shall be arranged for 6 alarm points high and 4 alarm point wide (Dual height light boxes). It shall be AMETEK-Panalarm Series 90A annunciator, Seekirk Series A1600, or approved equal.

iii. The annunciator operational sequence "AM" shall be:

Basic Flashing	Test or Alert	Silence	Acknowledge	Return to Normal	Reset Normal
Visual	Flashing	Flashing	Steady On	Steady Off	Off
Audible	On	Off	Off	Off	Off

iv. All modules shall be enclosed in a single, flush mounted cabinet, AMETEK- Panalarm Cat. #94CA34 or approved equal.

v. Eleven (11) light boxes shall be furnished and mounted on the front of the modules. Each light box shall control two alarm points and shall be equipped with two engraved, back lighted nameplates (1-7/16 inch H by 3-5/16 inch W) and two light bulbs for each alarm point. Light boxes shall be AMETEK-Panalarm Cat. No. 92LA01 with 92NP1WH nameplates, or approved equal.

vi. Twenty-two (22) cards, one for each alarm point, shall be furnished with optical isolators for 125 volt dc field contact voltage, polarizing protection key. Each card shall be AMETEK-Panalarm Cat. No. 91AF3KN125DC2Y ILT, or approved equal.

vii. One (1) flasher card shall be provided integral to the annunciator cabinet. Each flash card shall be AMETEK-Panalarm Cat. No. 90F1X1PB, or approved equal.

viii. One (1) integral power supply to provide 24 volt dc control voltage and 125 volt dc field contact supply voltage. The power supply shall be mounted in the lower right module in the annunciator. The power supply unit shall be AMETEK-Panalarm Cat. No. - 90P1X125DC125FC80W1PB1PL, or approved equal.

ix. Four (4) integral push-button station with "Test", "Silence", "Acknowledge" and "Reset" push buttons. The push-button station shall be mounted in the same module position as the power supply. The push-button station shall include a red “Power On” indication light. The push-button unit shall be AMETEK- Panalarm Cat. No. 90PB31PL1PL, or approved equal.

x. One (1) alarm horn. The horn shall be 125 volt dc, surface mounted type and shall have sixteen (16) selectable tones. The alarm horn shall be AMETEK-Panalarm Cat. No. NT2-24D, or approved equal

xi. One (1) automatic acknowledge card with external by-pass capability. The card to be mounted in slot "B" in the same module as the flasher card. The automatic acknowledge card shall be AMETEK-Panalarm Cat. No91LN1DNL12DC5FT4CE, or approved equal.

l. Sixteen (16) diodes rated 250 volt 20 ampere dc shall be provided in lockout (Dev.86) circuit, three (3) diodes rated at 250 volt, 5 amperes in conditional lockout relay circuit and six (6) diodes rated 250 volt 5 ampere dc with a 125 volt dc trouble relay (Dev. 74) for SCADA monitoring.

m. One (1) rectifier positive first step alarm relay (Device 26D1).

n. One (1) rectifier negative first step alarm relay (Device 26D1A).

o. One (1) rectifier positive second step high temperature conditional lockout trip relay, (Device 26D).

p. One (1) rectifier negative second step high temperature conditional lockout trip relay, (Device 26DA).

q. One (1) auxiliary to devices 26D and 26DA (Device 26X).

r. One (1) surge protection monitoring relay (Device 99Y).

s. One (1) lot ac and dc control power disconnects devices with overload protection, all rated 600 volt, (Devices 8 and 8R).

t. One (1) set of terminal blocks with 10 percent, but not less than 2, spare terminals.

u. One (1) stainless steel nameplate per IEEE Std. 1653.2

v. Interior lamps, 125 volt dc supply, LED with external on/off switch mounted on rectifier cabinet. Lamps shall be impact resistant and generally illuminate rectifier diodes, fuses and other internal devices.

2.03 TYPE AND QUANTITY OF EQUIPMENT REQUIRED

A. The Rectifiers shall be furnished as listed below:

1. At Broadway Substation:

a. Three (3) 2,500 kW, 600 volt dc silicon rectifier units; two (2) with ANSI circuit number 26 and one (1) with ANSI circuit number 25. Each rectifier shall be equipped as detailed in Paragraph 2.02 above, and shall be arranged for assembly as shown on the Drawings and tagged as follows:

i. “RECT. NO. 1” for circuit-26
ii. “RECT. NO. 2” for circuit-25
iii. “RECT. NO. 3” for circuit-26

2.04 DESIGN CALCULATIONS

A. The Contractor shall submit at design conference complete design calculations, which shall include, but not be limited to, the following:

1. Voltage Regulation Curve.

2. Power Factor - Load Curve.

3. Efficiency - Load Curve.

4. Harmonic Amplitude - Load Curve for 5th, 7th, 11th and 13th harmonics.

5. Commutation Reactance for X/R = 15.

6. Momentary Peak and Sustained Short Circuit Current.

PART 3 EXECUTION

3.01 INSTALLATION

A. See Section 34 21 10, Traction Power Equipment Installation, for the silicon rectifier installation requirements.

3.02 TESTING

A. See Section 34 21 11, Traction Power Equipment Testing, for the silicon rectifier testing requirements.

3.03 SUPPORT EQUIPMENT

A. See Section 34 21 09, Traction Power Support, for the support equipment requirements.

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 General and Special Conditions and Division 01 Specification sections, apply to this section.

1.02 SUMMARY

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.

C. 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 04, Traction Power 600 Volt DC Silicon Rectifier.
3. Section 34 21 09, Traction Power Support.
4. Section 34 21 10, Traction Power Equipment Installation.
5. Section 34 21 11, Traction Power Equipment Testing.

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 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.

i. 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.

ii. 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 fot 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. Hinged doors shall be provided at front and rear of each circuit breaker unit with a padlock, 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 2 stop positions, 90 degrees and 110 degrees to hold them securely in the open position. 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 Silicon Rectifier. If the short circuit exceeds the dc feeder breaker rating breaker rating, the Contractor shall determine and implement the method required to limit the short circuit current below the bus or the 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, and from the rectifiers.

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. 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. One (1) 125 volt dc sub distribution panel shall be installed in the auxiliary compartment. A separate circuit shall be provided from this panel 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.

U. An annunciator, (Device 130) with a capability of 24 points shall be provided in the auxiliary dc compartment to monitor various station alarms. It must be capable of operating and displaying all 24 alarms simultaneously. Separate terminal blocks shall be provided within the auxiliary dc compartment to accommodate all wiring from incoming alarms and outgoing to a substation SCADA RTU.

1. The annunciator shall be solid state, panel mounted, rear wired. Each module shall be equipped with cards, terminals and bus wiring for two annunciator points per module. All inputs to the annunciator shall be optically or electrically isolated from RTU and field contacts. The annunciator shall be arranged for 8 alarm points high and 3 alarm points wide (Dual Light Boxes). It shall be AMETEK- Panalarm Series 90A, or approved equal.

2. The annunciator operational sequence ("AM") shall be:

	Test or Alert	Silence	Acknowledge	Return to Normal	Reset Normal
Visual:	Flashing	Flashing	Steady On	Steady Off	Off
Audible:	On	Off	Off	Off	Off

3. All modules shall be enclosed in single, flush cabinet.

4. Twelve (12) light boxes shall be furnished and mounted on the front of the modules. Each light box shall control two alarm points and shall be equipped with two engraved, backlighted nameplates (not to exceed 1-7/16 inch H by 3-5/16 inch W) and 2 light bulbs for each alarm point.

5. Twenty four (24) cards, one for each alarm point, shall be furnished with an optical isolator for 125 volt dc field contact voltage, polarizing key. Each card shall be configured in the "Energized-in-normal" mode with on-board selected option to change to "De-energized-in-Normal" mode for both input to and output from the card by reconfiguring the jumper. Output contact shall be configured for "Contact-Follower-No-Test" mode.

6. One (1) flasher module shall be provided integral to the annunciator cabinet.

7. One (1) power supply unit, integral to the annunciator cabinet, shall be furnished to provide 24 volt dc control voltage and 125 volt dc field contact supply voltage.

8. One (1) remote mounted auxiliary relay shall be provided to initiate the alarm horn. Relays shall be furnished with 24 volt dc coils and 3 type "C" contacts.

9. Four (4) integral pushbuttons station with "TEST, "SILENCE, "ACKNOWLEDGE" and "RESET" pushbuttons. The pushbuttons shall be mounted in the same module position as the power supply. The pushbutton assembly shall include a red "Power On" indication light.

10. One (1) alarm horn, semi-flush panel mounted, rear wired. The horn shall be 125 volt dc. A surface mounted remote horn shall be furnished for each floor except the floor where the dc switchgear is located.

11. The annunciator shall be AMETEK-Panalarm Model 94A, sequence "AM" or approved equal. All wiring terminations to be ring style compression type and shall be accessible from the front of the cubicle.

V. 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.

W. 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.

X. 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. One (1) DC indicating voltmeter, 0-800V scale.

2. One (1) dc voltage transducer, complete with calibrating resistors, suitable for isolation of metering potential and supervisory telemetering, with rated input of 150 volt to 5 kV dc. Calibrating resistors may be added, if required and sized to produce 0 to 1.0 mA dc output and minimum 10 volt burden (10k ohm), calibrated for a 0-1000 volt dc input, Paladin 256 Series, Class 0.2 or approved equal. The transducer shall be fused separately.

3. One (1) set hot structure/ground detection equipment, including adjustable relays, associated devices and semiconductor rectifier type auxiliary dc power supply (copper oxide not acceptable) to furnish continuous supervision of switchgear enclosure from the station ground, rail negative and live switchgear components. The equipment also shall be arranged to give visual and audible alarm upon occurrence of positive potential of 75 volt or poor insulation to station grounding system for Devices 164C and 164X. Ground detection equipment must function without damage on structure potential up to 800 volt above ground potential. The alarm voltage and sensitivity shall be adjustable. Manual reset mechanical lockout is required for Device 164C.The relay shall be Swartz type, Model NO 2841-438.

4. One (1) annunciator with a minimum of 24 targets with audible alarm (Device 130).

5. 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.

6. One (1) 125 volt dc distribution panel with sixteen (16), 2 pole, 30 ampere circuits, to provide control power for each cubicle.

C. Each rectifier 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), 8,000 ampere air circuit breaker removable element with 11 or 12 stage auxiliary switch and instantaneous reverse current trip device(s),set at minimum value consistent with overall coordination and under-voltage trip device.

3. One (1), 10,000 ampere, 50 millivolt shunt with indicating ammeter, 0-20,000 ampere scale and calibrated leads.

4. One (1) dc current transducer, suitable of insulation of metering. Primary leads shall be sized, installed and calibrated in factory to produce 0-1 milliampere output through the 50 millivolt, 10,000 ampere shunt for 0-20,000 ampere dc current, Paladin 256 Series, Class 0.2 or approved equal.

5. Transducer must be located as close as possible to the shunt.

6. One (1) removable element position switch with required interchangeable stages.

7. One (1) permissive control switch (REMOTE-LOCAL), REMOTE position at 12 o'clock, LOCAL position clock-wise (Device 69).

8. One (1) control switch, with red and green indicating lamps (Close Right-Trip Left).

9. One (1) reverse current trip Swartz type 32 (Device 32).

10. One (1) second reverse current trip.

11. One (1) mechanical manual trip.

12. Where Indicated: Terminal lugs for 6-1/c 1500 kcmil copper, 2 kV EPR insulated, traction power cables.

13. Where Indicated: Bolted connections at the load side of the breaker to 8000 ampere internally mounted copper bus bars with flexible bus braids for connection to the rectifier. The bus, bus supports and mounting hardware as well as secure and safe method of mounting the bus. Coordinate with the rectifier supplier for connection at the rectifier end.

D. Each dc automatic re-closing feeder position shall be 18” wide and shall include, but not limited to:

1. One (1) metal enclosed stationary unit with 600 volt dc bus.

2. One (1) 6000 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).

   a. One (1) 6000 ampere shunt with bi-directional indicating ammeter, 12,000-0-12,000 ampere scale and calibrated leads for all feeder cubicles. For ELF cubicles, ammeter shall be unidirectional with 0-2000 ampere scale.

   b. One (1) removable element position switch with a minimum of 4 interchangeable stages.

4. One (1) control switch with red, green and amber indicating lamps (Close Right-Trip Left).

5. One (1) mechanical manual trip.

6. 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.

7. 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.

8. 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.

9. Disconnect switches for load measuring circuit (Device 108x) shall be rated for 800 volt dc.

10. 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, Class 0.2 or approved equal. The transducer shall be fused separately with a Ferraz type fuse disconnect or equal.

11. 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.

12. One (1) emergency close interposing relay (Device 201D) for remote closure of feeder breaker without load measuring.

13. One (1) master relay (Device 201X) operated both by local control and remotely by the Authority's supervisory control.

14. Terminal lugs for 3-1/c 1500 kcmil copper, 2 kV EPR insulated, traction power cable.

15. 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.

E. 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 6000 ampere air circuit breaker removable element shall be identical and interchangeable. One (1) spare 6000 ampere air circuit breaker removable element shall be supplied at each substation.

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 Broadway Substation:

   a. Item 1. One (1) - auxiliary compartment.

   b. Item 2. Three (3) - 8,000 ampere rectifier breaker positions.

   c. Item 3 Ten (10) 6,000 ampere automatic reclosing feeder breaker positions.

d. Item 4. One (1) - Spare 6,000 ampere air circuit breaker removable element. The breaker element shall not be incorporated into the dc switchgear lineup but shall be furnished loose.

e. Item 5. One (1) - Set of accessories including a remote racking device.

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.

END OF SECTION

SECTION 34 21 06
TRACTION POWER ANODE BUS DUCT

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Special Conditions and Division 01 Specification sections, apply to this section.

1.02 SUMMARY

A. This section covers the requirements for designing, manufacturing, testing, delivering and installing pre-assembled anode bus duct to be furnished for connecting traction power transformers to rectifiers. It consists of sections of 600 volt ac bus duct complete with flanges, taps, elbows, off sets, terminal connectors and associated accessories.

B. 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 03, Traction Power Rectifier Transformer.
3. Section 34 21 04, Traction Power 600 Volt DC Silicon Rectifier.
4. Section 34 21 10, Traction Power Equipment Installation.
5. Section 34 21 11, Traction Power Equipment Testing.

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 TECHNICAL REQUIREMENTS

A. Each bus duct assembly shall be metal enclosed, ventilated, non-segregated phase type, conforming to ANSI C37.23, except that an approved low impedance type bus duct may be applied as the anode bus, providing such requirement is dictated by the design of the transformer and rectifier package. The enclosure shall be fabricated from high strength, corrosion resistant aluminum or steel. Bus duct assembly installed on outdoor transformers shall be wind driven snow and rain resistant.

B. Removable covers shall be provided to allow access to the bolted bus connections and insulators for cleaning and inspection. Removable covers shall be secured with bolts to the frame.

C. Grounded bus ensclosure(s) shall be insulated from the high-resistance grounded rectifier enclosure by installation of boxed micarta or fiberglass section in the vertical portion at the rectifier, providing a minimum of six inches clearance between the metal enclosure of bus and nearest metal on rectifier. Alternate arrangement is insulated section in horizontal bus run, providing a minimum of two feet clearance between the metal bus enclosure and the nearest metal connected to the rectifier. In case of indoor/outdoor anodes buses, the insulated section must be installed indoors.

D. All metal work shall be thoroughly cleaned, treated against rust and corrosion, primed, bonderized and finished with two (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.

E. Two quarts of matching touch-up paint shall be shipped with each bus duct assembly.

F. Bus bars shall be of high conductivity rectangular copper with round edges finished to required size by cold rolling or drawing. Bus bars shall have uniform shape and dimensions, free from defects in material and workmanship. Bus bars shall be individually insulated, properly supported, and braced to each other and to the enclosure with approved, high quality, high strength, non-tracking insulators to withstand short circuit stresses to be encountered in use. All bus taps and connections shall be tightly bolted. Contact surfaces of bolted joints shall be factory silver plated. Bus connections and taps shall have an ampacity equal to that of the bus ampacity, and fabricated so that there will be no loss of conductivity during the life of the bus.

G. The 600 volt ac anode bus duct assemblies shall conform to ANSI C37.23 and meet the following requirements:

a. Rated maximum voltage: 635 volt, maximum
600 volts, nominal

b. Rated insulation level
power frequency withstand: 2.2kv (for one minute, dry)

H. Buses shall be rated to carry continuously the current of associated rectifier transformer and rectifier operated at 160 percent of rated full load. The temperature of the bus bars shall not exceed maximum limit of 105 degrees C under these loading conditions. The bus duct assembly shall be compatible in design and construction with the provisions made at the transformer and rectifier and shall operate as an integral unit when assembled.

I. The temperature rise of bus bars at the hottest spot for the specified duty shall not exceed 65 degrees C over an ambient of 40 degrees C, thus limiting the maximum operating temperature of bus conductors to 105 degrees C.

J. The bus shall be designed to safely withstand equipment short circuit currents without damage to either the conductors or the enclosures. Busway shall have an insulation system that will withstand 2200 volt, 60 Hz for 1 minute, after being thoroughly wetted, between each bus bar and between each bus bar to enclosure; and shall then have a minimum of one mega ohm resistance, using a 1000 volt megger.

K. At both transformer and rectifier, flexible bus terminations shall be provided. The termination details shall be fully coordinated with the manufacturer of rectifier transformer and rectifier.

L. Bus duct assemblies shall be supplied complete with connection flanges, taps, elbows, insulated housing sections, offsets, splicing plates, terminal connectors, and associated accessories and in length as required by the final approved arrangement drawings. The shipping section shall be pre-assembled in the factory so that minimum installation is required at site. It is the responsibility of the Contractor to furnish the equipment as specified here and shown on the Contract Plans so that they can be installed as a system without any modifications or requiring additional materials and labor at site, except to carry out the manufacturer's installation instructions.

M. All hardware required to make the field connections between sections and terminations to the equipment shall be furnished in sufficient quantity.

N. Suitable support of bus enclosures shall be provided as may be required to ensure rigid structure and workmanlike installation of the system. Support of the bus duct shall be designed and coordinated with the manufacturer of rectifier transformer and silicon rectifier so there is no need for any external additional supports connected to any portion of the substation building.

2.02 QUANTITY OF EQUIPMENT REQUIRED

A. At Broadway Substation:

1. Three (3) sets of 600 volt ac metal enclosed ventilated non-segregated anode bus duct to carry 160 percent of rectifier transformer and rectifier full load current.

PART 3 EXECUTION

3.01 INSTALLATION REQUIREMENTS

A. See Section 34 21 10 for installation requirements.

3.02 TESTING REQUIREMENTS

A. See Section 34 21 11 for testing requirements.

END OF SECTION

SECTION 34 21 07
TRACTION POWER SUBSTATION BATTERIES AND ASSOCIATED ACCESSORIES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Special Conditions and Division 01 Specification sections, apply to this section.

1.02 SUMMARY

A. This section covers the requirements for manufacturing, testing and delivering of indoor station batteries, battery chargers and battery racks for the traction power substations. The batteries will serve as the primary source of 125 volts dc control power for the rectifiers, ac and dc switchgears, as well as SCADA.

B. 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 09, Traction Power Support.
3. Section 34 21 10, Traction Power Equipment Installation.
4. Section 34 21 11, Traction Power Equipment Testing.

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 TECHNICAL REQUIREMENTS

A. Batteries:

1. The batteries shall supply the high discharged rates necessary to close both ac and dc switchgear after it has supplied the lower discharge rates demanded by indicating lights and relay coil loads with ac bus dead for 12 hours.
2. The batteries sizing shall be based upon:
   a. Charger failure with substation in full operation.
   b. Startup after ac voltage failure with the line breaker open and which must be closed before voltage to charger is restored.

c. 500 watts emergency lighting load and 200 watts continuous supervisory load.

d. Continuous load of 15 amperes.

e. 20 percent derating factor for aging of battery and temperature effects.

f. Substation operation from 55 degrees F to 104 degrees F.

g. Battery discharged to 1.75 volts/cell.

3. The Contractor shall calculate battery required for 12 hour reserve but in no event shall battery size be less than 200 AH to 1.75 volt per cell at an 8 hour rate.

4. The batteries must give long, satisfactory life (20 to 30 years) and require minimum maintenance and repairs.

5. The batteries shall have 100 percent guaranteed capacity at the time of energizing substation.

6. The batteries must deliver no less than 80 percent at rated output during Warranty period.

7. Under normal conditions, the addition of water shall be necessary no more than twice per year.

8. Each substation lead acid control batteries shall be of the lead calcium or lead selenium plate design; 123 volts dc open circuit (2.05 volts dc per cell), 60 individually cased cells; equal in quality and performance. The batteries shall be C & D type KCR or approved equal.

9. Each cell shall be individually housed in clear plastic container (1 cell per battery unit) of extra strength to reduce weight and space requirements and to provide a complete view of cell interior so that the level of electrolyte and plate condition can be easily seen.

10. Each cell shall have a sediment space of 0.75 inches or greater and positive plate thickness of 0.260 inches or greater to insure long life.

11. The height of the electrolyte above plates shall be no less than 2 inches to ensure low watering frequency.

12. The cells shall have high/low level lines on all jar faces.

13. The safety vents shall be provided to prevent an explosion of internal cell gases due to an external spark or flame.

14. The batteries shall be shipped wet or dry charged with the electrolyte provided in durable containers suitable for storage at the site.

15. Manufacturer’s storage, handling, charging, commissioning and testing procedures must be followed. Failure to adhere to manufacturer’s procedures may result in batteries being rejected. The Contractor is cautioned that wet charge batteries may require charging and periodic maintenance while in storage. Furthermore, commissioning of dry charged batteries typically require voltages well above normal float and equalize voltage that may require voltage levels beyond that available from the battery charger. Dry charged batteries shall not be given an initial charge while connected to substation equipment.

16. The Contractor must perform monthly voltage readings and quarterly specific gravity readings on all cells until the station is turned over to Authority.

17. Hydrometer with wall mounting bracket.

18. Two (2) pilot cell thermometers, mounted one in each battery rack step.

19. The batteries shall be furnished with acid resistant nameplates, indicating name of manufacturer, year/month of manufacture, cell type and Ampere hours (on 8 hour base).

20. All inter-cell and inter-step connectors, bolts and terminal lugs shall be lead plated.

21. One acid-resistance identification tag shall be supplied for each cell. Tags shall be numbered 1 through 60, starting with "1" at the negative end and finishing with "60" at the positive end of battery.

22. The batteries set shall be assembled, filled and put into operation under the supervision of this Contractor and witnessed by the Authority's Testing Department.

23. The Contractor will be required to supply a temporary set of batteries (10 automotive batteries) to supply 120 volt dc control power during battery replacement and commissioning. Temporary batteries may use the existing float charger.

B. Battery Charger:

1. The battery charger shall be of the controlled ferroresonant constant voltage rectifier type, complete with voltmeter and ammeter, rated according to associated battery size at 133 volts dc to fully recharge the battery in twenty (20) hours or less, but in no case less than 25 amperes at 133 volts dc. The battery charger shall be similar to C & D Technologies, Model ARE 130AC25F.

2. DC voltage shall be maintained within +/-1 percent at any load from no load to full load with +/-10 percent variation in the ac input voltage and 57 to 63 Hz while floating rated number of cells, minus one or plus one.

3. Unit shall be equipped with equalizing charger timer 0-72 hours, to terminate a manually set equalizing charger and low voltage alarm relay to indicate ac and dc failures. Equalizing charger for 60 cell battery shall be nominal 141 volts dc adjustable +/-10 percent.

4. The battery charger shall be current limiting, adjustable down to 90 percent and up to 115 percent; factory set to 110 percent.

5. AC voltage shall be single phase 208 volts, and shall have a low voltage battery alarm.

6. Current and voltage indicating meter.

7. The meters, breakers, and timer dial shall be accessible from front of charger without the need of panel removal or door opening.

8. The battery charger shall have both an ac circuit breaker for the input and a dc circuit breaker for the output.

9. The low voltage battery alarm should be on the load side of the dc circuit breaker monitoring the voltage of the batteries, with indicating lights for low voltage battery alarm, set alarm to SCADA when battery voltage falls below 121 volts, reset above 127 volts.

C. Batteries Rack:

1. Each battery rack shall be 2-step type configuration, 30 cells each level.

    a. Rack shall provide sufficient space above each cell for access with standard hydrometer, thermometer, and maintenance.

2. The battery rack shall be industry standard design and should not include side or end restraining rails.

3. The battery rack shall be fabricated from steel iron or rectangular steel tubing, powder coated with ANSI #61 gray acid—resistant epoxy paint and shall be supplied with snap-on insulating plastic strips to cover all support rails.

4. The overall length of the battery rack shall not exceed thirteen feet.

2.02 QUANTITY OF EQUIPMENT REQUIRED

A. One (1) set of 60 cell (individually cased) substation control batteries complete with mounting racks and battery chargers shall be furnished and delivered to the Broadway substation site.

PART 3 EXECUTION

3.01 INSTALLATION

A. See Section 34 21 10, Traction Power Equipment Installation, for the station batteries and associated accessories installation requirements.

3.02 TESTING

A. See Section 34 21 11, Traction Power Equipment Testing, for the station batteries and associated accessories testing requirements.

3.03 SUPPORT EQUIPMENT

A. See Section 34 21 09, Traction Power Support, for the station batteries and associated accessories list of support equipment.

END OF SECTION

SECTION 34 21 08
TRACTION POWER DC DISTRIBUTION PANEL

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Special Conditions and Division 01 Specification sections, apply to this section.

1.02 SUMMARY

A. This section covers the requirements for manufacturing and delivering of dc distribution panels.

B. 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 TECHNICAL REQUIREMENTS

A. DC distribution panelboard shall be rated for 125 volt dc for a 2 wire service with a short circuit rating of 10,000 amperes minimum.

B. Main bus shall be of 225 ampere copper sized in accordance with U L Standard to limit temperature rise in any current carrying part to a maximum of 65° degrees C above an ambient of 40° degrees C maximum.

C. Circuit breakers shall be 2-pole thermal-magnetic type with a minimum of 10,000 ampere dc interrupting rating.

D. Bolt-in type, heavy duty, quick-make, quick-break, 2-pole circuit breaker shall be provided for each circuit with toggle handles that indicates when unit has tripped.

E. Interiors shall be completely factory assembled devices. They shall be designed such that switching and protective devices can be replaced without disturbing adjacent units and without removing the main bus connectors.

F. Trims for the panelboards shall be supplied with a hinged door over all circuit breaker handles. Doors in panelboards trims shall not uncover any live parts. Doors shall have a semiflush cylinder lock and catch assembly. Doors over 48 inches in height shall have auxiliary fasteners.

G. Panelboard trims shall cover all live parts. Switching device handles shall be accessible.

H. Surface trims shall be same height and width as box. Flush trims shall overlap the box by H.3/4 of an inch on all sides.

I. A directory card with clear plastic cover shall be supplied and mounted on the inside of each door. The directory card shall be neatly typed with destination clearly identified for each circuit.

J. Each panelboard shall be factory assembled and furnished with 2-pole feeder or branch circuit breakers with the following trip rating:

1. One (1) - 125 ampere breaker
2. Three (3) - 60 ampere breakers.
3. Six (6) - 30 ampere breakers.
4. Four (4) - 20 ampere breakers.
5. Three (3) - 15 ampere breakers.

K. The panelboards shall be as manufactured by the General Electric, Type CCB with Type TED4 (100A frame) and Type TKJ (225A frame) breakers; Cutler-Hammer, Type CDP with Type EHB (100A frame) and JB (225A frame) breakers; or Square D Type QMB with Type KA (225A frame) breakers; or approved equal.

2.02 QUANTITY OF EQUIPMENT REQUIRED

A. One (1) DC distribution panelboard shall be furnished for the Broadway substation.

PART 3 EXECUTION – NOT USED

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 General and 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. Section 34 21 03, Traction Power Rectifier Transformer.
2. Section 34 21 04, Traction Power 600 Volt DC Silicon Rectifier.
3. Section 34 21 05, Traction Power 800 Volt DC Switchgear.
4. Section 34 21 06, Traction Power Anode Bus Duct.
5. Section 34 21 07, Traction Power Substation Batteries and Associated Accessories.
6. Section 34 21 19, Traction Power 15 KV AC 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 following items of rectification equipment 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. One (1) percent of each type (minimum of one (1) per rectifier supplied) of diode, diode fuses and diode commutating capacitors used in the rectifiers.

2. Two (2) surge arrester assemblies of each type used.

3. 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).

4. For each type of AC and 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.

5. 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.

6. One (1) diode fuse monitor relay.

7. One (1) rectifier transformer 49 device.

8. Two (2) lightning arrestors of each type.

9. Rectifier bimetallic thermal devices and accessories, one (1) first step and one (1) second step.

10. One (1) of each type of springs used in each type of breaker furnished.

11. One (1) of each type of relays in use with all traction power conversion equipment included in this Specification.

12. Station control battery charger of highest current rating supplied, only one (1) per Project.

13. One (1) set primary and two (2) sets of secondary rectifier power transformer bushings and/or standoff insulators, only one (1) per Project.

14. Power monitoring package similar to HDPQ-XAMFLEX6PKG, as manufactured by DRANTZ or approved equal including ac adapter-118317-G1, USB-MCABLE, USB BLUETOOTH, 118313-G1 Keyhole mounting kit, voltage cable set-118375-G1, DRANFLEX300MHB6 single phase flex probe, SCC-HDPQ soft carry case and Dran-View 7 DV7E-PX software package. Only one (1) per Project.

15. MPC-800 cable and magnetic locator kit as manufactured by Schonstedt or approved equal, only one (1) per Project.

16. For each type of fuses supplied for traction power equipment, furnish minimum of 10 percent but not less than four (4).

17. Two (2) load measuring relays and one (1) simulator for testing and troubleshooting purposes.

18. One (1) SEL-451 and one (1) SEL-551 relay.

19. One (1) annunciator, Device 30 with 22 points and 11 light boxes as described in Section 34 21 04, Paragraph 2.02 C.11 of this Specification.

20. One (1) annunciator, Device 130 with 24 points and 12 light boxes as described in Section 32 21 05, Paragraph 2.01 U of this Specification.

21. One (1) of each of the various types of transducers in use with all traction power conversion equipment included in this Specification.

22. One (1) set of the following items.

    a. Cell lifter

    b. Hydrometer

    c. Thermometer

    d. Bolt wrenches

    e. Two (2) solderless connectors for #2/0 copper cables

    f. Four (4) spare intercell connectors with bolts and nuts

    g. Syringe

    h. Battery strap

    i. Thermal grease

23. Additional test sets and software to set, test and calibrate all electronic relays, load measuring, 150,164 or 64C and X, SEL-551, annunciators, etc, Schweitzer AC SELerator QuickSet SEL5030 software.

24. Automatic Transformer Winding Analyzer for three phase power and distribution transformer measurement manufactured by Haefely Hipotronics model #2293. Only one (1) per Project.

25. One (1) SEL Relay Tester manufactured by Doble, model # F6150sv

26. Two (2) safety solid white LED lights, including wall mounting bracket so light is visible from the floor, to indicate the presence of dc voltage with sufficient length to reach all dc cubicles, similar to PROTRAN “Pro light” PT-001 DC or approved equal.

27. One (1) RD8100-PTLG Cable Locater manufacture by SPX Radiodetection or approved equal, including soft carrying case-10/LOCATORBAG, rechargeable battery mains kit-10RX/MBATPACK-LION-K, rechargeable battery pack-10/RX-BATPACK-ION and signal clamps 10/RX-CLAMP-2, 10/RX-CLAMP-4, 10/RX-CLAMP-5 and 10/RX-CD-CLAMP.

28. 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 a three (3) day, 24 hour course to 40 CTA personnel, in two sessions (20 personnel per session), in Chicago on circuit theory operation, maintenance, and troubleshooting procedures. 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 as follows:

1. The intent of the training program 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.

2. This training program shall consist of both Classroom and Practical (Field) Training. It shall be broken down into Traction Power Elements arranged in a sequential fashion from the incoming line to output of the third rail system. The training program shall also encompass maintenance procedures, problem setups and troubleshooting exercises. Maintenance sequence and frequency shall also be presented. Standardized training methods, acceptable to the industry shall be applied.

3. Sequence of Learning Objectives.

   a. Sequence of learning objectives shall be to provide a safe overview followed by general electrical technical knowledge, print reading, symbols and abbreviations. Once general knowledge has been developed with the students, the course shall be site specific concentrating on single line diagrams, theory of operations, and control schematics

   b. Upon completion of the classroom theory sessions the training course shall concentrate on details of each specific piece of equipment and its function for the following: ac switchgear, dc switchgear, rectifier/transformer, rectifiers, meters, relays and control devices

4. The training schedule for the date and time will be coordinated with the Authority. The Authority will supply the facility for the training, both classroom and at the site of the Traction Power Substation. Completion of training is required as a condition for achieving Final Acceptance

C. The Contractor shall also provide a three (3) day, 24 hour course to 20 CTA personnel, in Chicago on SEL relay training.

PART 3 EXECUTION – NOT USED

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 General and 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 03, Traction Power Rectifier Transformer.
3. Section 34 21 04, Traction Power 600 Volt DC Silicon Rectifier.
4. Section 34 21 05, Traction Power 800 Volt DC Switchgear.
5. Section 34 21 06, Traction Power Anode Bus Duct.
6. Section 34 21 07, Traction Power Substation Batteries and Associated Accessories.
7. Section 34 21 08, Traction Power DC Distribution Panel.
8. Section 34 21 19, Traction Power 15 KV AC 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. AC Switchgear

1. The 15,000 volt ac switchgear shall be fully assembled and completely installed in accordance with the manufacturer's instructions at the location shown on the Contract Plans.
2. Switchgear base channels shall be furnished and installed in the floor slab in accordance with the manufacturer's instructions. The switchgear units shall be anchored to the base channels with sufficient number of bolts to withstand impact resulting from breaker operations.
3. Switchgear units shall be assembled in such a manner as to insure proper leveling, proper alignment between the various shipping groups and for proper placements of all the required primary circuit conduits that are required for equipment interconnection.

4. Breaker test cabinets shall be installed at the locations shown on Contract Plans. 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 be drilled and tapped for mounting the test cabinets using galvanized bolts.

5. After completion of switchgear installation, the Contractor shall ensure that all doors and draw out fuse and PT carriages 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.

B. Rectifier Transformer

1. Rectifier transformers shall be fully assembled and completely installed in accordance with the manufacturer's instructions at location shown on Contract Plans.

2. Low voltage terminals of the transformers shall be connected to the anode bus duct specified in Section 34 21 06, Traction Power Anode Bus Duct.

C. Rectifiers and Accessories

1. Rectifier units shall be fully assembled and completely installed in accordance with the Authority's approved manufacturer's drawings at locations shown on Contract Plans.

2. Insulated anchors shall be furnished and installed in the floor slab in accordance with the manufacturer's instructions. The floor area at the rectifier units will be covered with a layer of insulating materials, to insulate the rectifier enclosure from building structure. Care shall be taken that the insulated floor area is not scraped or otherwise damaged during installation. After completions of the installation, the rectifier enclosure shall be completely insulated from the building structure.

3. Rectifier units shall be connected to the rectifier transformer via the ac anode bus duct and to the rectifier dc main circuit breaker in the dc switchgear as shown in the Contract Drawing, either through the internal bus or external cables. Rectifier negative terminals shall be connected to the negative bus and from the negative bus to the drainage bus, by means of cables.

D. 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. The rectifier main circuit breakers units shall be connected to the rectifiers either by means cable or internal bus as shown on the Contract Drawings.

5. 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.

6. 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.

7. 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.

E. Anode Bus Ducts

1. The bus ducts interconnecting rectifier transformers to the rectifier assemblies shall be fully assembled and completely installed in accordance with the approved manufacturer's drawings and as shown on Contract Drawings.

2. Bus ducts shall be fully supported by the rectifier enclosure and the rectifier transformer enclosure. External supports connected to any portion of the substation building shall not be allowed.

3. All ferrous elements of the support system shall be hot dipped galvanized. Hanger supporting ungrounded portions of anode buses shall be provided with approved insulators to insulate the bus enclosures from the building structure.

4. Bus ducts shall be assembled in such manner as to insure proper alignment between the shipping sections and the equipment they connect. After alignment and leveling, the bus enclosure shall be bolted to the equipment and then the enclosure splice plates shall be attached and securely fastened.

5. Insulated bus enclosure sections shall be installed in the rectifier anode bus runs to isolate the rectifier enclosure from its transformer.

6. Before connections are made, all contact surfaces shall be wiped clean (sandpaper or abrasive tools shall not be used) and covered with a thin coat of approved grease. Joints in bus conductors shall be made using splice plates on each side of the conductor. Connections to equipment terminals shall be made with flexible connectors as specified. All joints shall be made with a minimum of four 1/2 inch by 13 high tensile strength silicon bronze bolts and nuts. All nuts shall be provided with approved locking devices. All bolts shall be tightened to the manufacturer’s recommended torque value with a calibrated torque wrench.

7. After completion, all joints shall be covered by die-molded, flame retardant polyvinyl chloride boots, or approved equal, providing full voltage insulation for the joint. These

boots shall be easily removable for inspection of the joint without destruction of the boot.

F. Station Batteries, Charger and Accessories

1. Station batteries shall be provided with, and installed on a 2-step rack.

2. Battery rack shall be installed at location shown on Contract Plans. Battery rack shall be assembled from steel members, suitably clamped and braced. All members shall be thoroughly cleaned and rust proofed powder coated with ANSI #61 gray acid – resistant epoxy paint. The rack shall be insulated with plastic channel fastened with double-sided adhesive tape for mounting the battery cells. Each cell on the rack shall be numbered with approved, clearly visible numerals. Numbers shall start from battery negative end and finishing with “60” at the positive end of the battery terminal.

3. The Contractor shall remove the battery cells from shipping and inspect each cell for damage. The Contractor shall fill the cell with electrolyte of 1.21 specific gravity in accordance with the manufacturer’s recommendations.

4. Cells shall be set on rack with plates at right angles to the rails. Cells shall be spaced on the racks so that the intercell connectors can be installed without stressing the cell posts. All current carrying surfaces shall be scraped bright and clean and covered with a thin film of approved grease. Bolts shall be tightened to proper tension and the surplus grease wiped off. After completion of all connections, the polarity of each cell shall be checked with a voltmeter.

5. The Contractor shall install the battery charger unit at locations shown on Contract Plans or as directed by the Authority.

6. After the completed installations is tested and checked out in accordance with the manufacturer's installation recommendations and all applicable portions of Section 34 21 07, Substation Batteries and Associated Accessories, the battery shall be given a freshening charge to assure that all cells are fully charged. When the charging cycle is completed, the Contractor shall read and record the specific gravity and voltage of each cell and temperature and electrolyte level of three cells and furnish the Engineer five neatly typed copies of the readings for the record.

G. DC Distribution Panel

1. The dc distribution panel shall be installed at the location shown on Contract Plans. A clear space of 1/4 inch, minimum, shall be provided between the back of the panel and the wall. Steel channels or straps, or equal, of suitable thickness shall be fastened to the masonry and drilled and tapped for mounting the panel using galvanized machine bolts.

2. The circuit directory shall be neatly typed identifying the destination and cable number for each circuit as well as identifying the spare circuits.

PART 3 EXECUTION – NOT USED

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 General and 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 tests 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. AC Switchgear

1. Following tests listed in ANSI C37.09 as "Design Tests" shall be conducted on one 15kV class representative circuit breaker:

a. Rated maximum voltage test

b. Rated voltage range factor test

c. Rated frequency test

d. Rated continuous current carrying tests

e. Short-circuit rating tests

f. Rated standard operating duty tests

g. Rated permissible tripping delay tests

h. Rated interrupting time tests

i. Rated reclosing time tests

j. Dielectric withstand tests

i. Low frequency withstand voltage test

ii. Impulse withstand voltage tests

k. Low current switching tests

l. Radio influence voltage tests

2. Following tests listed in ANSI C37.09 as "Production Tests" shall be conducted at the manufacturer's facility on each and every 15kV class circuit breaker:

a. Current and linear coupler transformer tests

b. Nameplate check

c. Resistors, heaters, and coil check tests

d. Control and secondary wiring check tests

e. Clearance and mechanical adjustment check tests

f. Mechanical operation tests

g. Timing tests

h. Stored energy system tests

i. Electrical resistance of current path test

j. Low frequency withstand voltage tests

3. Following tests listed in ANSI C37.20 as "Design Tests" shall be conducted on the 15kV metal clad ac switchgear assembly:

a. Dielectric tests

i. Power Frequency withstand tests

ii. Impulse withstand test

iii. Test of busbar insulation

b. Rated continuous current tests

c. Momentary current tests

d. Mechanical operation tests

e. Flame-retardant tests

4. Following tests listed in ANSI C37.20 as "Production Tests" shall be conducted at the manufacturer's facility on the 15kV metal clad ac switchgear assembly:

a. Mechanical operation tests

b. Grounding of instrument transformers cases test

c. Electrical operation and control wiring tests

i. Control wiring continuity test

ii. Control wiring insulation test

iii. Polarity tests

iv. Sequence tests

5. In lieu of Design Tests specified above for ac circuit breakers and ac switchgear assembly, test certificates from the manufacturer or an independent agency conducted on similar circuit breakers and similar switchgear assemblies are acceptable, provided test certificates meet the specification requirements in the opinion of the Authority.

C. Rectifier Transformer

1. Following tests listed in IEEE Standard C57.12.91 shall be conducted at the manufacturing facility on each and every rectifier transformer to be furnished in this Contract:

   a. Cold resistance measurement test on all windings on the rated voltage connections and at all taps per C57.12.91 Section 5.4.

      i. Pass/Fail Criteria.

      $$\left[\frac{3(Rmax\text{-}Rmin)}{R1+R2+R3} \right] X\ 100 \leq 5\%$$

   b. Polarity and phase relation test at rated voltage connection.

      i. Pass/Fail Criteria per attached Table.

   c. Ratio test on the rated voltage connection and at all taps, per C57.12.91Section 7.3.

      i. Pass/Fail Criteria: per attached Table.

   d. No load loss and excitation current test at 90%, 100% and 110% rated tap voltage per C57.12.91 Section 8.2

      i. Pass/Fail Criteria per attached Table.

   e. Load loss and impedance voltage test at 90%, 100% and 110% rated tap voltage.

      i. Pass/Fail Criteria per attached Table.

   f. Dielectric test:

      i. Insulation resistance test per C57.12.91, Section 10.9.

         i) Pass/Fail Criteria per attached Table.

      ii. Insulation power factor test:

         i) Pass/Fail Criteria per attached Table.

      iii. Applied voltage (H1-Pot) test per C57.12.91, Section 10.3

         i) Pass/Fail Criteria per attached Table.

      iv. Induced voltage level test (To be performed after impulse test) per C57.12.91, Section 10.4.

         i) Pass/Fail Criteria per attached Table.

   g. Impulse test consisting of reduced, 2 chopped and full wave applied to high and low voltage winding per C57.12.91, Section 10.5. Pass/Fail Criteria: per IEEE C57.98.

   h. Partial discharge test. Corona inception and extinction levels on all primary terminals.

i. Pass/Fail Criteria: Corona inception shall not occur at less than 125 percent above the highest voltage connection (maximum winding). Extinction must be at least 15 percent above the highest voltage connection.

2. Following tests shall be conducted at the manufacturer's facility on one representative transformer of each size. Tests shall be performed on delta primary unit:

a. Temperature rise test to determine that the temperature rise of the windings are within the permissible limit after delivering full load continuously and fulfilling the rectifier-transformer duty cycle. For the purpose of this test, readings will be considered to have stabilized when the rate of temperature rise is less than two degree Celsius during a consecutive 3 hour period. The test shall be performed per Standard C57.12.91.11.5 in the following sequence:

i. Step 1:

i) Temperature stabilized at 100% continuous load at lowest voltage and highest current tap. This temperature will be used as a base line for the remaining temperature rise test.
ii) Record data at shut down.

ii. Step 2:

i) Re-stabilize the temperature at 100% continuous load.
ii) Apply 300% full load current for 36 minutes.
iii) Record data at shut down.
iv) Pass/Fail Criteria: Hot spot temperature shall not exceed 180 degrees Celsius in an ambient corrected to 40 degrees Celsius.

iii. Step 3:

i) Re-stabilize the temperature at 100% continuous load
ii) Apply 162% full load current for 2 hours.
iii) Record data at shut down.
iv) Pass/Fail Criteria: The temperature rise shall not exceed 80 degrees Celsius in an ambient corrected to 40 degree Celsius.

iv. <u>Step 4</u>:

i) Re-stabilize the temperature at 150% continuous load.
ii) Record data at shut down.
iii) Pass/Fail Criteria: The temperature rise shall not exceed 85 degrees Celsius in an ambient corrected to 40 degrees Celsius.

v. <u>Step 5</u>:

i) Apply 1200% full load current for 12 seconds.
ii) Pass/Fail Criteria: No physical or electrical damage should occur.

b. Audible sound level test in accordance with IEEE Standard C57.12.91, Section 13. The transformer shall be connected for and energized at rated voltage and frequency at no load. Pass/Fail Criteria less than 65 dB (A).

D. Rectifier

1. Following tests listed in IEEE Std. 1653.2 Section 11 shall be conducted at the manufacturing facility on each and every rectifier furnished under this Contract.

   a. Dielectric voltage test per IEEE Std. 1653.2 Section 11.3.1.6

      i. Pass/Fail Criteria: No momentary flashover to ground, no external flashover to ground, no excessive noise and no excessive leakage current.

   b. Rated voltage test. The test to be performed with 110% of rated input voltage applied for 5 minutes per IEEE Std. 1653.2 Section 11.3.5

      i. Pass/Fail Criteria: Recorded vac values between R_1, R_2 and R_3 match expected value of the ac voltage.

   c. Rated current test per IEEE Std. 1653.2 Section. 11.4.2.

      i. Pass/Fail Criteria: The rectifier conducts 110% of its rated current without any incident. The temperature should be the same as recommended for regular service.

   d. Current balance test at 150 percent full load current. With 150 percent full load applied and temperatures stabilized measure temperature of ambient air-in and air-out, temperature of each of 4 selected diodes and their associated heat sinks (use same positions on each unit) and current in each diode.

      i. Increase current by 7 percent waveform and conduction angle adjustment factor to compensate for loading by short circuit. Pass/Fail Criteria per attached table.

   e. The following certified test or manufacturer's certified test data for the diode (per device) units of the rectifier shall be furnished to the Authority.

      i. Average forward current rating, per ANSI 282A.

      ii. Peak forward current rating.

      iii. Maximum surge current rating.

      iv. Forward voltage drop.

      v. Threshold voltage.

      vi. Differential resistance.

      vii. Crest working voltage.

      viii. Working peak reverse voltage rating, per ANSI 282A.

      ix. AC RMS voltage rating.

      x. DC voltage blocking rating, per ANSI 282A.

      xi. Repetitive peak reverse voltage rating, per ANSI 282A (PRV rating).

      xii. Non-repetitive peak reverse voltage rating, per ANSI 282A.

      xiii. Initial reverse voltage.

xiv. Forward power loss.

xv. Reverse power loss.

xvi. Temperature derating.

xvii. Positive non-conducting period.

xviii. Surge forward current rating per ANSI 282A.

xix. Operating temperature rating, per ANSI 282A.

xx. Thermal fatigue rating, per ANSI 282A

E. 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

      i. Electrical endurance test

      ii. 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

      i. Direct acting trip devices

      ii. 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

      i. Control wiring insulation tests

      ii. Polarity tests

      iii. Sequence tests

F. Bus Duct

1. Following tests shall be conducted at the manufacturer's facility on one unit as specified under "Design Tests" in ANSI C37.23 for metal-enclosed bus.

   a. Dielectric tests

      i. Power frequency withstand

      ii. Impulse withstand

   b. Temperature rise tests

   c. Momentary tests

2. In addition, temperature rise test described below shall be conducted on one representative anode bus duct.

   a. Measure temperature rise of conductors in 40 degrees Celsius ambient at continuous 150 percent rated load, load to be applied until all readings have stabilized. This test may be performed concurrent with the in-line tests specified for rectifier package tests, provided the readings have stabilized during the two hour application of 150 percent load. For the purposes of this test, readings will be considered to have stabilized when the rate of temperature rise is less than two degree Celsius during a consecutive 3 hour period.

3. Insulation and Moisture Test (Outdoor Bus Duct only).

a. One complete bus duct shall be mounted as it would be in normal service. Install spray nozzle to permit thorough wetting of all interior parts.

b. Apply 2200V, 60 Hertz bar to bar and each bar to enclosure for one minute.

c. Measure insulation resistance bar to bar and each bar to enclosure using a 1000V megger.

d. Spray all internal parts until thoroughly wetted for 2 hours.

e. Apply 2200V, 60 Hertz for 1 minute.

f. Measure insulation resistance as in step (c) above.

4. Power Frequency withstand test shall be conducted at the manufacturer's facility on each and every shipping length as specified under "Production Test" in ANSI C37.23 for metal-enclosed buses.

G. Auxiliary Transformers

1. In addition to the test normally performed by the manufacturer and tests called for in the applicable IEEE, ANSI, and NEMA standards, a prototype test shall be performed on one auxiliary transformer unit consisting of the tests outlined in the Transformer Test Table that is included as part of this specification..

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 done using the latest revision of all equipment drawings. Perform test to prove the correctness of all control, protection and indication circuits in the ac switchgear, dc switchgear, rectifiers, and transformers.

2. Each and every ac and dc circuit breaker 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. Perform phantom load tests on ac switchgear protective devices to ensure calibration as outlined in Section 34 21 01. Calibration test also shall be performed on:

a. Item 1 - All 600V dc auxiliary compartments

b. Item 2 - All 600V dc rectifier breaker positions

c. Item 3 - All 600V dc automatic reclosing feeder breaker positions

d. Item 4 - All Spare 600V dc air circuit breaker removable element.

6. Perform short circuit tests at Broadway Substation on rectifier, ac and dc switchgears to ensure calibration of rectifier, ac switchgear and dc switchgear protective devices, and overall coordination of protective devices as outlined in Section 34 21 01 and to confirm adequate short-time current capability of dc circuit breakers. Short circuit tests shall be conducted with rectifiers in service. Circuit breaker of suitable rating furnished by Contractor may be used as a shorting device. "Astromed Dash 8" or equal recording instrument shall be used to record time constant etc. Parameters for each test shall be recorded and furnished with field test reports. Clipping of waveform will not be acceptable. Conduct the tests as follows:

   a. Energize all rectifiers in the Substation in parallel. Short-circuit output terminals of one of the rectifiers. Check for proper protective device coordination and fault isolation as follows:

      i. Main rectifier dc circuit breaker of short-circuited rectifier should be tripped by its instantaneous reverse overcurrent trip device, Device 32, to clear the fault supplied from all other rectifiers operating in parallel.

      ii. Device 32 shall also trip the ac circuit breaker of short circuited rectifier to clear the fault supplied from ac system.

      iii. Protective devices of parallel operated rectifier shall not operate during this test.

      iv. Results of test such as total inrush current, steady-state fault current, impulse time of faulted unit, clearing time of faulted unit, and primary system voltage and short circuit capacity shall be tabulated.

   b. Repeat the test describe above in Paragraph 3.01.C 6a for each of the remaining rectifiers. Check for proper protective device coordination and fault isolation and tabulate the results.

   c. Energize any one of the rectifiers in the substation with its main dc breaker closed and close the dc feeder breaker specified by Engineer. Short circuit the load side of the closed dc feeder breaker. For proper protective device coordination and fault isolation, dc traction feeder breakers instantaneous series overcurrent trip device, Device 176, shall trip the faulted feeder breaker and successfully clear the fault. No other breakers should trip. Tabulate results such as total let-through current and total clearing time, and record primary system voltage short circuit capacity.

   d. Repeat the above test energizing the other rectifiers one by one and short circuit load side of the Engineer Specified dc feeder breaker. For proper protective device coordination and fault isolation, dc traction feeder breaker instantaneous series trip device, Device 176, shall trip the faulted feeder breaker and successfully clear fault. No other breakers should trip. Tabulate the results of each test as outlined above.

e. Energize all rectifiers in the Substation in parallel closing their respective main (rectifier) dc circuit breakers. Close the dc feeder circuit breaker specified by Engineer. Short circuit the load side of the closed dc feeder circuit breaker. For proper protective device coordination, fault isolation and dc breaker interrupting capability demonstration, Device 176, shall trip the faulted feeder breaker and successfully clear fault. No other breakers should trip. Tabulate the results of test as outlined above.

f. Energizing any one of the rectifiers in the Substation and close the main (rectifier) dc circuit breaker. Short circuit the load terminals of the main (rectifier) dc circuit breaker. For proper protective coordination, rectifier ac circuit breaker of the faulted unit shall be tripped by ac feeder time overcurrent unit of relay Device SEL-551. The short circuit current will flow until interrupted by the ac circuit breaker. Tabulate the results.

7. Perform short circuit test from Broadway Substation on one section going north with Calvary Substation section open and one section going south with Clifton Substation section open. Short circuit tests shall be performed on sections with the contact rail shorted at the remote end.

a. All sectionalizing switches in the section shall be closed and all auxiliary loads such as switch heaters, contact rails heaters, and emergency lighting etc. shall remain connected.

b. Using "Astromed Dash 8” or equal recording instrument the circuit "time constant" (L/R) shall be determined for each section and recorded. These "circuit time constants" shall be used for the rate of rise relay settings on each appropriate section.

8. Failure of the equipment to withstand these tests shall be sufficient grounds for rejection of equipment.

TRANSFORMER TESTS						
TEST DESCRIPTION	**STANDARD**	**PASS/FAIL CRITERIA**	**ROUTINE**	**DESIGN**	**NOTES**	**AUX TX**
Commutating Reactance	IEEE C57.18.10			XXXXX		
Resistance of all windings at all taps	IEEE C57.12.91 Section 5.4	Per IEEE C57.12.91.5	XXXXX	XXXXX		XXXXX
Polarity and phase relation at nominal voltage tap	IEEE C57.12.91 Section 6.3	Per IEEE C57.12.91.6.3.1	XXXXX	XXXXX		XXXXX
Turns Ratio of all windings at all taps	IEEE C57.12.91 Section 7.3	Per IEEE C 57.12.01.9.1 Tolerance +/- 0.5% all taps	XXXXX	XXXXX		XXXXX
No load loss and excitation current @ 90%, 100% and 110% of nominal tap voltage	IEEE C57.12.91 Section 8.2	5.1 kW for 2808 KVA 6.0 kW for 3370 KVA	XXXXX	XXXXX		
Impedance voltage of all windings at all taps	IEEE C57.12.91	Per IEEE C 57.12.01.9.2		XXXXX		
Load loss of all windings at all taps	IEEE C57.12.91 Section 9.3	Per IEEE C 57.12.01.9.3		XXXXX		

TRANSFORMER TESTS (continued)						
TEST DESCRIPTION	**STANDARD**	**PASS/FAIL CRITERIA**	**ROUTINE**	**DESIGN**	**NOTES**	**AUX TX**
Load loss of all windings at nominal voltage tap and tap extremes	IEEE C57.12.91	Per IEEE C 57.12.01.9.3	XXXXX			
Impedance voltage of all windings at nominal voltage tap and tap extremes	IEEE C57.12.91	Per IEEE C 57.12.01.9.2	XXXXX			XXXXX
Insulation Resistance; H.V.-L.V. & earth ground L.V.-H.V. & earth ground Core – Earth ground	IEEE 57.12.91.10.9	Windings > 1000Mohm Core > 100Mohm	XXXXX	XXXXX		XXXXX
Insulation Power Factor	C57.12.91.10.8	Per C57.12.91.10.8				
Applied voltage	IEEE C57.12.9.10.3 IEEE C57.12.01	No change in measured current	XXXXX	XXXXX		XXXXX

TRANSFORMER TESTS (continued)						
TEST DESCRIPTION	**STANDARD**	**PASS/FAIL CRITERIA**	**ROUTINE**	**DESIGN**	**NOTES**	**AUX TX**
Induced Voltage (Performed after impulse test)	IEEE C57.12.91.10.4 IEEE C57.98	C57.12.91.10.4	XXXXX	XXXXX	LV winding at 2X rated voltage	
Temperature Rise at 100% at lowest voltage, highest current tap	IEEE C57.12.91 CTA spec 16603	No specified value		XXXXX	Used as a baseline for the remaining temperature rise tests	XXXXX
Temperature Rise at 150% at lowest voltage, highest current tap	IEEE C57.12.91 CTA spec 34 21 03	85 degrees Celsius		XXXXX	Corrected to 40 deg. C ambient	
Temperature Rise at 162% at lowest voltage, highest current tap	IEEE C57.12.91 CTA spec 34 21 03	80 degrees Celsius		XXXXX	Corrected to 40 deg. C ambient	
Temperature Rise at 300% at lowest voltage, highest current tap	IEEE C57.12.91 CTA spec 34 21 03	Hot spot < 145 deg. C for epoxy, 180 deg. C for VPI		XXXXX	Corrected to 40 deg. C ambient	
1200% short circuit withstand at highest voltage, lowest current tap	CTA 34 21 03	No Damage		XXXXX		

TRANSFORMER TESTS (continued)						
TEST DESCRIPTION	**STANDARD**	**PASS/FAIL CRITERIA**	**ROUTINE**	**DESIGN**	**NOTES**	**AUX TX**
Impulse (H.V. winding), Reduced, chopped and full wave. Minimum winding, highest tap.	IEEE C57.12.91.10.5 IEEE C57.12.01 IEEE C57.98	IEEE C57.98.2.5 IEEE C57.98.2.8	XXXXX	XXXXX	110 kV BIL	XXXXX
Impulse (L.V. winding), Reduced, chopped and full wave	IEEE C57.12.91 IEEE C57.12.01 IEEE C57.98	IEEE C57.98.2.5 IEEE C57.98.2.8	XXXXX	XXXXX		
Partial Discharge (Corona Inception/Extinction)	IEEE C57.12.91	PD < 10 pC	XXXXX	XXXX		XXXXX
Audible Noise	IEEE C57.12.91	< 65 d.b.a.		XXXXX		
Thermal Shock (Cast Coil Only)	CTA 34 21 03	No damage		XXXXX	Cast Coil Only	

RECTIFIER TESTS					
TEST DESCRIPTION	**STANDARD**	**PASS/FAIL CRITERIA**	**ROUTINE**	**DESIGN**	**NOTES**
Dielectric strength	IEEE 1653.2, Section 11.3.1	No flashover	XXXXX	XXXXX	

RECTIFIER TESTS (continued)					
TEST DESCRIPTION	**STANDARD**	**PASS/FAIL CRITERIA**	**ROUTINE**	**DESIGN**	**NOTES**
Rated Voltage	IEEE 1653.2, Section 11.3.5	No failure	XXXXX	XXXXX	
Rated Current	IEEE 1653.2, Section 11.3.7	Diode junction temperature shall not to exceed maximum rating	XXXXX	XXXXX	
Efficiency	IEEE 1653.2, Section 8.1	Per specification Section 34 20 04		XXXXX	
Voltage Regulation (At 0.5%, 25%, 50%, 75%, 100%, 150%, 300% and 450% load	IEEE 1653.2, Section 8.2	Per specification Section 34 20 04		XXXXX	
100% Current Balance (N diodes)	IEEE 1653.2, Section 8.4	+20% Max per section +/- 10% Max between sections		XXXXX	
150% Current Balance (N diodes)	IEEE 1653.2, Section 8.4	+20% Max per section +/- 10% Max between sections	XXXXX	XXXXX	

RECTIFIER TESTS (continued)					
TEST DESCRIPTION	**STANDARD**	**PASS/FAIL CRITERIA**	**ROUTINE**	**DESIGN**	**NOTES**
Power Factor	IEEE 1653.2, Section 8.3	Per IEEE 1653.2.8.3		XXXXX	
Harmonic Amplitude	IEEE 519	THD < 5% Individual < 3%		XXXXX	
Commutation Reactance Constant	IEEE 1653.2 Annex B	Per IEEE 1632.2 Annex B		XXXXX	
150% Diode Temperature	CTA 34.21 04	Diode junction temperature shall not exceed maximum rating		XXXXX	

END OF SECTION

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

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)

Transformer Turns Ratio Tester

PHASE IA – AC SWITCHGEAR

Following tests to be performed by Equipment Supplier:

1) AC Breaker Racking Mechanism Function
   - Withdraw breaker and move on own wheels
   - Confirm interchangeability within station including spares
   - Physical inspection

2) AC Breaker Mechanism check and operation
   - Manual spring charging close – open breaker, slow close breaker
   - Test of Kirk key interlock
3) 1000V Megger Test
   - Perform megger test (resistance test) on each side of each circuit breaker for one minute.
   - Megger control wiring to skin 1000V dc for one minute.

4) AC Switchgear Hipot
   - With all breakers racked in closed, carry out the following tests (Be sure to disconnect load cables).
     - Phase A to B + C + Ground – 27kV ac (38kV dc) for one minute.
     - Phase B to A + C + Ground – 27kV ac (38kV dc) for one minute.
     - Phase C to A + B + Ground – 27kV ac (38kV dc) for one minute.
   - Hipot Incoming ac cables (ComEd’s responsibility).
   - Check ac breaker vacuum canister for breakdown.
   - Check for contact resistance.

5) Physical Inspection of ac Switchgear

PHASE IB – RECITIFIER TRANSFORMER AND AUXULIARY TRANSFORMER

Following tests to be performed by rectification equipment supplier

1) Physical inspection Transformers (Rectifier and Auxiliary Transformers)

2) 1000V Megger Test

   a. Primary to ground
   b. Secondary to around
   c. Primary to secondary

3) HIPOT (Auxiliary and Rectifier transformers on highest tap)

   a. HIPOT primary to ground, 27kV ac (38kV dc) for 1 minute
   b. HIPOT secondary to ground, 1875V ac (2650V dc) for 1 minute.
   c. HIPOT control wiring to ground, 1125V ac (16000V dc) 1 minute.

4) Transformer Turn Ratio Test at all taps

PHASE 1C – RECTIFIER

Following tests to be performed by traction power equipment supplier

1) Physical inspection including instruments and heat sink assemblies.

   Check torques per instruction manual.

2) Megger rectifier power busses and power busses and power bus duct conductors to skin.

3) Megger control wiring to skin 1000V dc for 1 minute.

PHASE ID – 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 IE – BUS DUCT

Bus duct testing must be coordinated with Phase 1B (Rectifier Transformer) and Phase 1C (Rectifier)

1) Physical inspection of bus duct

2) Megger bus duct bars to skin, with skin connected to ground

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 – CONTROL BATTERY, BATTERY CHARGER AND CONVERTER

Battery test should be performed here.

Since control power is necessary to nearly all aspects of Phase II test, this test should proceed before all other aspects of Phase II.

Following tests to be performed by traction power equipment supplier.

1) Check battery specific gravity and connections.

2) Inspect charger, turn on at no load. Check input/output voltage, adjustments (float, equalizer, etc.). Physical inspections. Connect charger. Charger set to recommended rate per manufacturer's instructions.

3) Check motor/generator set

4) Adjust to proper voltage

PHASE IIB – AC SWITCHGEAR

Following tests to be performed by equipment supplier.

1) Calibrate and bench test for accuracy by applying appropriate power to all ac overcurrent relays in accordance with the equipment supplier coordination sheet.

2) Test for accuracy of all voltmeters, ammeters and transducers

3) Check all functions position. Begin with incoming line feeders and tie breaker point. Yellow line in on elementary diagrams.

4) Check PT/CT connections by secondary injection. Line in on elementary diagrams.

5) Perform CT Saturation Test

6) Perform PT ratio test

7) Simulate relay output from relay test plug. Line in on elementary diagrams.

8) Confirm electrical operation of all breakers, including test stations.

PHASE IIC – RECTIFIER TRANSFORMER

The following checks should be made after the ac switchgear and battery have been tested as outlined. All elementary diagrams must be line in completely. Record all readings on elementary diagrams.

Following tests to be performed by equipment supplier.

1) Winding Temperature Indicator – Check set point, alarm and trip function. Check reset temperature, annunciate and lockout.

2) Verify accuracy of rectifier transformer winding temperature indicators by applying heat gun.

3) Check proper function of transformer door interlock system.

PHASE IID – RECTIFIER

The following checks should be made after the ac switchgear has been tested as outline above. Battery and inverter (if used) must be operative. Tests should be made through an annunciator board and dc switchgear tripping. All elementary diagrams must be lined in completely. If complete system verification cannot be made at once. Check out portion of system and line in. Record all readings on elementary diagram.

Following tests to be equipment supplier.

1) Demonstrate operation of 64 device both ground (64X) and hot structure (64C). Record pickup, dropout voltage, and circulating current for all ground and hot structure.
2) Check continuity of sensor and simulate both and alarm.
3) Check surge protection by operating micro switch.
4) Check door interlock system by opening and closing doors.
5) Check diode fuse monitor (alarm and trip) by operating micro switches on fuse indicator. Check function of test switch on fuse monitoring indicator.
6) Check rectifier negative switch (89N) and interlocks for proper operation.
7) Check proper operation of all rectifier alarms.

PHASE IIE – 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 IIF – 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. AC switchgear
   b. Rectifier transformers (HV/LV/GND)
   c. Bus duct
   d. DC feeder connections
3) Visually check protective relay settings.
   a. AC switchgear
   b. DC switchgear (including recloser)
4) Open all breakers. Rack dc breakers to disconnect position. Open negative disconnect switches in rectifier and negative switchgear. Put all breaker controls in local. Check all switchgear and access panels for tightness. Close and latch all cubicle doors.
5) Close rectifier feeder breakers and confirm tripping by operating test switch on diode fuse monitor. Confirm annunciator horn is on.
6) Close incoming feeders. Observe ac switchgear instrumentation and relaying.
7) Set transformer taps. Remove kirk keys. Reset thermometer drag pointers.
8) Close rectifier feeder no. 1
   Close rectifier feeder no.2

   Leave closed for 3 – 4 hours

   - Check transformer for any ticking or hissing noise. Also check core noise level is within acceptable limits. This test to be performed on separate transformer test program as per ANSI-C.57.
   - Visually check diode fuse monitor, fuse switches, and annunciators
   - Visually inspect bus duct

- Record transformer primary current and voltage, transformer secondary voltage and rectifier dc voltage.

9) Open rectifier ac feeder breaker no. 1
Close and open rectifier no. 1 five times at no load (allow complete discharge of rectifier voltage). Observe diode fuse monitor and fuse switches after each close.
Close rectifier feeder breaker no. 1

10) Open rectifier ac feeder breaker no. 2
Close and open rectifier no. 2 five times at no load (allow complete discharge of rectifier voltage). Observe diode fuse monitor and fuse switches after each close.
Close rectifier feeder breaker no. 2

11) Open both ac rectifier feeders. Close anode switches in rectifiers. Remove kirk keys. Rack in cathode breakers. Close rectifier feeder’s no. 1 and 2. (Cathode breakers slave close). Make measurements as indicated in Step 8.

12) Repeat steps 9 and 10.

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.

PHASE IV – SHORT CIRCUIT TEST

Test to be performed be installation Contractor.

Following tests to be performed at all new substation equipment

1) Visually inspect equipment meters, gauges etc. Pay particular attention to diode fuse monitor.
2) De-energize station. Put all controls to local. Connect timing circuits, back up trip and recording instruments.
3) Open al dc feeder breakers. Close ac rectifier feeder breakers. (Cathode breaker slave close). Simulate operation shorting switch and back up timers. Check recording devices.
4) De-energize station. Connect shorting switch between dc positive bus and negative bus.
5) Close and latch all switchgear doors. Close incoming ac line and rectifier feeder breakers. (Cathode breakers slave close).
6) Calibrate current and voltage on recording meter.
7) Apply short circuit between dc bus and negative switchgear bus. Record currents and voltages on recording meter.
8) Continue short circuit tests for the following conditions:
   a. With one (1) rectifier in service make a short circuit at the load terminals of that rectifier's dc circuit breaker. The short circuit current with flow until interrupted by the ac circuit breaker under control of the ac protective relays.
   b. With two (2) rectifiers in service, make separate short circuit between each rectifier and its associated dc breaker to prove coordination between that rectifier dc breaker reverse current trip and opposite unit ac breaker relays.
   c. With one (1) rectifier in service make separate short circuits on each rectifier on load side of a selected number of dc feeder breakers to prove coordination between dc feeder breaker series overcurrent trips and rectifier ac breaker relays.
   d. With two (2) rectifiers in service make separate short circuits on each rectifier on load side of a selected number of dc feeder breakers to prove coordination between dc feeder breaker series overcurrent trips and rectifier ac breaker relays.
   e. Remote fault test on specified sections shall be performed to determine circuit time constant.
      1. Short circuit tests shall be performed on selected sections with the contact rails shorted to negative rails at the remote end.
      2. All sectionalizing switches in the section will be closed and all auxiliary loads such as switch heaters, contact rail heaters, emergency lighting etc. shall be disconnected.
      3. Using "Astromed Dash 8" or equal recording instrument the circuit time constant (L/R) shall be determined for each section and recorded these circuit time constants shall used for the rate of rise relay settings on each appropriate feeder breaker.

TEST REPORT

PHASE IA **<u>AC Switchgear</u>**

SUBSTATION:

SERIAL: TESTED BY:

DATE OF TEST: verified by:

1. MECHANICAL/VISUALITY/INTERCHANGEABILITY
   BREAKER RACKS IN:

   BREAKER RACKS OUT:

   INTERCHANGEABILITY:

   MECHANICAL CHECK:

   SPRING CHARGING:

ITEM/REMARKS	VALUE	STATUS

2. HI-POT
   PHASE A TO B + C+ GROUND
   PHASE B TO A + C +GROUND:
   PHASE C TO A + B+ GROUND:
   VACUUM CANISTER CHECK:

3. MEGGER

   PHASE A TO B + C + GROUND
   PHASE B TO A + C + GROUND:
   PHASE C TO A + b + GROUND:

4. CONTACT RESISTANCE

   PHASE A
   PHASE B
   PHASE C

TEST REPORT (continued)

PHASE IB **Rectifier Transformer**

SUBSTATION:
SERIAL NO: TESETED BY:
DATE OF TEST: VERFIED BY:

ITEM/REMARKS	VALUE	STATUS
1. Visual/mechanical checks		
2. Megger:		
a. Primary to ground	MOhm	
b. Secondary to ground	MOhm	
c. Primary to secondary	MOhm	

Remarks:

TEST REPORT (continued)

PHASE IC <u>Rectifier</u>

SUBSTATION:
SERIAL NO: TESTED BY:
DATE OF TEST: VERIFIED BY:

1. <u>MECHANICALLY/VISUALLY</u>

	ITEM/REMARKS	VALUE	STATUS
2.	Megger rectifier with positive Bus bar to skin connected to ground	MOhm @1000V dc	
	Remarks: Phase A,B and C Pos. And Neg. all shorted out. Remove Cathode breaker open neg. switch		
	a. Megger rectifier cubicle to ground.	MOhm @1000V dc	
	Remarks		
3.	Megger rectifier control wiring To skin connected to ground.	MOhm @1000V dc	
	Remarks: All control wires Interconnected at the terminals.		

TEST REPORT (continued)

PHASE ID **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, 1000V AC	w/o Motor 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

PHASE IE **<u>Bus Duct</u>**

SUBSTATION:
SERIAL NO: TESTED BY:
DATE OF TEST: VERIFIED BY:

1. MECHANICALLY/VISUAL CHECK

	ITEM/REMARKS	VALUE	STATUS
2.	Megger ac bus between RT And rectifier to ground	MOhm @1000V DC	
	Value with links connected Included with RT test 1B, 2B		

TEST REPORT (continued)

PHASE IIA **Control Battery, Charger and Converter**

SUBSTATION:
SERIAL NO: TESTED BY:
DATE OF TEST: VERFIED BY:

ITEM/REMARK	VALUE	STATUS
1. Battery inspection		
a. "No Smoking" signs		
b. Ventilation		
c. Alignment and spacing		
d. Check tightness of all connections		
e. Check positive to negative connection of each cell		
f. Fill out battery data sheet for each cell after initial charge		
2. Charger		
a. Record serial number		
b. Check instrumentation/inspection/connection		
c. Input voltage check at phases	V AC	
d. Float setting	V DC	

TEST REPORT (continued)

PHASE IIA **<u>Battery Data Sheet</u>**

SUBSTATION:
SERIAL NO: TESTED BY:
DATE OF TEST: VERIFIED BY:

Battery V DC (NO LOAD)

CELL	VOLT	SPEC	TEMP	LEVEL	CELL	VOLT	SPEC	TEMP	LEVEL
1					31				
2					32				
3					33				
4					34				
5					35				
6					36				
7					37				
8					38				
9					39				
10					40				
11					41				
12					42				
13					43				
14					44				
15					45				
16					46				
17					47				
18					48				
19					49				
20					50				
21					51				
22					52				
23					53				
24					54				
25					55				
26					56				
27					57				
28					58				
29					59				
30					60				

TEST REPORT (continued)

PHASE IIA **<u>Control Battery, Charger and Converter</u>**

SUBSTATION:
SERIAL NO: TESTED BY:
DATE OF TEST: VERIFIED BY:

	ITEM/REMARK	VALUE	STATUS
1.	Charger		
	a. Equalize setting	V dc	
	b. Function check of switch timer		
	c. Loss of charger alarm. (Pickup__V dc: Dropout___ Vdc)		
2.	Inverter set check (as applicable)		
	a. Record serial number		
	b. Input voltage		
	c. Physical inspection meters/connection		
	d. Voltage		
	e. By-pass functioning		

TEST REPORT (continued)

PHASE IIB **AC Switchgear**

SUBSTATION:
SERIAL NO: TESTED BY:
DATE OF TEST: VERIFIED BY:

1. Relays Calibrated
2. Control checks verified
3. Electrician operation all breakers

TEST REPORT (continued)

PHASE IIC **Rectifier Transformer**

SUBSTATION:

SERIAL NO: TESTED BY:

DATE OF TEST: VERIFIED BY:

ITEM/REMARKS	VALUE	RESET VALUE	STATUS
1. Winding temperature 49T. 49 TH.			
Remarks: a. Alarm at….	degC	degC	
Remarks: b. Trip at….	degC	degC	
Remarks: 49 TH			
2. Transformer Door Alarm: 33T			

TEST REPORT (continued)

PHASE IID Rectifier

SUBSTATION:
SERIAL NO: **TESTED BY:**
DATE OF TEST: **VERIFIED BY;**

ITEM/REMARKS	VALUE	STATUS

1. 64 Device
   a. Ground (Pickup)______VDC: Dropout_____VDC: Circulating Current__ mA)
   b. Structure (Pickup)_____VDC: Circulating Current___ mA)

2. Rectifier Thermostats

   Alarm Continuity:

   a. Trip Continuity:

3. Surge Protection

   a. Inspection/Fuse
   b. Micro Switch

4. Door lock interlock all doors

5. Diode Fuse monitor
   a. Control power indicator
   b. Test switch (all LED)
   c. Control power failure
   d. One blown fuse per leg (all 6 legs)
6. Kirk key interlock, if necessary
7. Inspection

TEST REPORT (continued)

PHASE IIE **<u>DC Switchgear/DC Breaker inspection</u>**

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 IIE **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:
DATE OF TEST:

TESTED BY:
VERIFIED BY:

ITEM/REMARK	STATUS	VERIFIED BY
1. Previous test data and System elementary diagram reviewed		
a. AC switchgear -Phase IA -Phase IIA		
b. Rectifier transformer -Phase IB -Phase IIB	RT1 RT2 RT3	
c. Rectifier -Phase IC -Phase IIC	R1 R2 R3	
d. DC switchgear -Phase ID -Phase IID		
e. Bus duct -Phase IE		
f. Annunciator and metering Phase IIF		

TEST REPORT (continued)

PHASE IIIA **<u>Traction Power Substation</u>**
<u>Pre-Energization Check List</u>

SUBSTATION:
SERIAL NO: TESTED BY:
DATE OF TEST; VERIFIED BY:

	ITEM/REMARKS	STATUS	VERIFIED BY
2.	Final check all connections		
	a. AC switchgear		
	-Incoming feeders	No.1 No.3	
	-Rectifiers feeder	No.1 No. 2 No.3	
	b. Rectifier transformer	RT1 RT2 RT3	
	-HV connection		
	-LV connection		
	-GND		
	c. Rectifier	R1 R2 R3	
	-AC incoming		
	-Bus		
	-Diode/fuses		
	-Positive		
	-Negative		
	d. Bus duct		
	-RT 1 to R1		
	-RT 2 to R2		
	-RT 2 to R2		
	e. 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. Switchgear		
	-Incoming feeder	No.1 No.2	
	-Rectifier feeder-Bus tie		
	b. DC switchgear	Protection Reclosure	
	-RB No.1		
	-RB No.2		
	-RB No.3		
	-Feeder A		
	-Feeder B		
	-Feeder C		
	-Feeder D		
	-Feeder E		
	-Feeder F		
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		

TEST REPORT (continued)

PHASE IIIA **Substation Energization Record**

SUBSTATION:
SERIAL NO: TESTED BY;
DATE OF TEST: VERIFIED BY:

Transformer Primary Volts

	AB	BC	CA
RT #1			
RT#2			
RT#3			

Transformer Primary Currents

	A	B	C
RT#1			
RT#2			
RT#3			

TEST REPORT (continued)

PHASE 111A Substation Energization Record

SUBSTATION:
SERIAL NO: TESTED BY:
DATE OF TEST: VERIFIED BY:

Transformer Secondary Volts

	AB	BC	CA
RT#1			
RT#2			
RT#3			

Rectifier DC Volts

RT#1	
RT#2	
RT#3	

SECTION 34 21 12
TRACTION POWER IN-LINE TEST ON RECTIFICATION EQUIPMENT
AND SURGE AND DESTRUCTIVE TEST ON DIODES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the contract, including General and Special Conditions and Division 01 Specification sections, apply to this section.

1.02 SUMMARY

A. This section covers the requirements for in-line test on rectification equipment and surge destructive test on diodes.

B. All the applicable requirements of Part 1 "General" of Section 34 21 11, “Traction Power Equipment Testing” shall apply to this Section.

PART 2 DETAIL REQUIREMENTS FOR IN-LINE TEST

2.01 IN-LINE TEST

A. General

1. If facilities for conducting the in-line tests are not available to the manufacturer, these tests shall be conducted elsewhere or by an independent agency as approved by the Engineer. Contractor shall, however, clearly indicate in the proposal the name of the facility, where the tests would be conducted.

2. The transformer and rectifier assembly shall be complete with all necessary hardware wiring, control and alarm monitoring devices as indicated and required for a complete and operating installation.

B. Rectifier surge voltage and short-circuit tests

1. Following test shall be conducted on one (1) rectifier package, including transformer, rectifier and interconnecting anode bus assembled in line and subjected to the following tests to ensure compliance with specification requirements. Test set-up shall include primary supply system having minimum 150MVA capacity, switchgear having operating characteristics equivalent to actual switchgear specified, protective devices having operating characteristics equivalent to actual devices specified and which have been adjusted to provide pick-up values and operating times conforming to those proposed for final installation, as well as shunt, properly calibrated meters, shorting devices, loading devices and other associated appurtenances as may be required.

a. Open circuit test to insure ability to withstand transient surge voltages in steps as follows:
i. Energize transformer and rectifier at rated voltage with no load.
ii. De-energize transformer and rectifier by tripping ac supply breaker.
iii. Record voltage waveforms and amplitudes at transformer and rectifier output terminals and at critical points in surge protection network during close and trip operation.
iv. Repeat test a minimum of 10 times to insure maximum transient.
v. Maximum crest of transient surge impressed on rectifier shall not exceed 75 percent of the voltage withstand of the diodes in a phase leg.

b. Short circuit test to determine short circuit current in steps as follows:
   i. Energize transformer and rectifier at rated voltage with no load.
   ii. Short rectifier output terminals with shorting device.
   iii. Clear short (bolted fault) by tripping the ac supply breaker through equivalent ac switchgear protective devices.
   iv. Record current waveform and amplitude at rectifier output terminals during shorting operation.
   v. Calculate theoretical values of peak and sustained short circuit currents for rated voltage fault on a 500 MVA system having X/R ratio of 15. Calculate theoretical transformer over-voltage and test supply system X/R ratio required to obtain a minimum of these values on actual test set-up.
   vi. Repeat short circuit test with transformer energized at theoretical over-voltage and the X/R ratio of the test supply system adjusted to the value calculated in 5 above. Continue to adjust voltage until calculated peak and sustained values of current are realized.

C. Rectifier Current Balance and Load Test

1. Following test shall be conducted on one (1) rectifier package, including transformer, rectifier and interconnecting anode bus assembled in line and subjected to the following tests to insure compliance with the Specification requirements. Test setup shall include necessary supply and loading systems including switchgear and protective devices, ventilation system equivalent to actual system in final installation as specified with temperature controlled at 104 degrees Fahrenheit, shunts, thermocouples, properly calibrated meters, and associated appurtenances as may be required. 125 volt dc control power shall be provided to the control circuits of the rectifier in order to keep thermal devices energized during the test. Reduced voltage-reduced capacity supply system will be acceptable for certain portions of these test providing currents specified are increased by 7 percent waveform and conduction angle adjustment factor to compensate for loading by short circuit. Individual silicon diode junction temperatures shall not exceed design values established, in Contractor's load and short circuit calculations as determined from actual case temperature using junction versus case temperature data.

   a. Current balance test to insure compliance with requirement for current balance between diodes sharing current of same polarity in steps as follows:
      i. Attach six thermocouples, 1 per leg and apply 100 percent full load current and measure all diode currents in each phase polarity. After stabilization of temperature, repeat test for 150 percent (N diodes).
      ii. Remove 1 diode fuse in each phase polarity to create maximum diode current unbalance; then apply 150 percent full load current and measure remaining diode currents in each phase polarity, after stabilization of temperature.

   b. Efficiency measurement test. The test shall be performed on each rectifier at 100% rated load per IEEE Std. 1653.2 Section 8.1. Efficiency shall be determined by calculation based on measured losses on 100% rated load, for rated voltage, current and frequency.

   c. Voltage regulation test shall be performed at 0.5 percent load, 25 percent load, 50 percent load, 75 percent load, 100 percent load, 150 percent load, 300 percent load and 450 percent load per IEEE Std.1653.2 Section 8.1.

   d. Harmonic amplitude test per I IEEE Std. 519.

e. Load current test to insure compliance with rectifier current rating (thermal capability) and ability of rectifier to withstand short circuit under load in steps as follows:
   i. With 1 diode fuse removed in each phase polarity as in test above, apply 100 percent full load current until constant diode temperature is reached. Measure and record current and temperature of 2 diodes, which had maximum current.
   ii. Apply 150 percent full load current for two (2) hours immediately after completion of the 100 percent full load current test above.
   iii. Superimpose five (5) one-minute overloads of 300 percent full load current spaced equally throughout the 2 hour period followed by one 15 second overload of 450 percent full load current at the end of the two hour period.
   iv. Apply short circuit current, obtained in the short circuit test (2.01.B.1.b.6) for the operating time of the short time relays plus ac breaker opening time in cycles immediately after completion the test (2.01.C.1.b.3) above. A time interval of 1 second is allowed between the 450 percent overload and the application of short circuit.
   v. Record load current, ambient air temperature, supply air temperature, discharge air temperature, transformer winding hot spot temperature and diode case temperature of diode having maximum current unbalance as determined in the current balance test (2.01.C.1.a.2) at sufficiently close time intervals to provide accurate current - time - temperature relationship.
   vi. Monitor rectifier commutation with Astromed Dash 8 recorder during- test loadings set forth in test (2.01.C.1.b.3) above to insure normal operation. If possible, trace rectifier input voltage wave forms.
   vii. Failure of equipment to withstand tests or to meet ratings shall be sufficient grounds for rejection of equipment.

D. Commutation Reactance

1. Determine the commutation reactance and resistance of the rectifier package (transformer, rectifier and anode bus) using any one of the following three propositions so that the equipment voltage regulation may be calculated ($E_D = E_{DO} - E_{TH} - E_X - E_R$ = average dc voltage) under load to insure compliance with output voltage characteristics set forth in this Specification. For definitions applicable to the following see Paragraph 2.01 D.1.d.

   a. Proposition I:
      i. Transformer, bus duct, and rectifier connected in-line.
         i) Ambient of entire package adjusted and maintained at 40 degrees C.
         ii) With rectifier dc output terminals shorted, adjust and maintain transformer primary current while at 12,600 volt tap at 100 percent I_P at 60 Hz until the hottest spot winding temperature stabilizes (not more than 2 degrees C rise in a consecutive 3 hour period).
         iii) Measure input watts "P", ac amperes "I_P", ac volts “V”, dc amperes "I_d" and the voltage across the shorting strap "V_d."
         iv) Determine X for Package as follows:

$$X \sec = \frac{\sqrt{\left(\sqrt{3}VI_P\right)^2 - P^2}}{3I_p^2}\left(\frac{E_s}{E_p}\right)^2\left(\frac{ohms}{phase}\right)$$

v) Determine R for Package as follows:

$$R = \frac{\left[P - I_d\left(V_d + 2E_{TH}\right)\right]}{3I_P^2}\left(\frac{E_s}{E_p}\right)^2\left(\frac{ohms}{phase}\right)$$

b. Proposition II:

i. Transformer at 12,600 volt ac taps set up for certified heat run.

i) Measure primary and secondary resistances at any ambient. Note ambient temperature (T_1).

ii) With transformer secondary open circuited, energize primary of transformer at rated voltage and frequency until individual winding temperature stabilizes. Measure average winding temperature by resistance method. Determine temperature rise T_e.

iii) With transformer secondary short circuited, circulate rated full load current in primary until transformer winding temperature rises do not change more than 2° C during a consecutive 3-hour period.

iv) Measure input watts "P", ac amperes "I_p", and ac volts 'V.'

v) Shut down and quickly measure dc resistance of primary and secondary windings. Record elapsed time between instant of shut-down and each resistance measurement. All reading must be completed within 4 minutes of shut-down. Otherwise the temperature test should be resumed until temperature is normal again, after which the remaining readings will be taken.

vi) Determine temperature rise of copper winding and correct R for 40 degrees Celsius ambient.

Let R_1 = resistance (step a) at copper temperature t_1.

R_2 = resistance at 100 percent I_p continuous and test ambient.

t_2 = copper temperature at 100 percent I_p continuous and test ambient.

R_3 = resistance at 100 percent I_p continuous and 40 degrees Celsius ambient.

t_3 = copper temperature at 100 percent I_p continuous, normal excitation on the core and 40 degrees Celsius ambient.

$$t_3 = t_3 + \left(40 - TEST\ AMBIENT\right) + T_{\overline{C}} - T_C$$

$$T_{\overline{C}} = T_C\left[1 + \left(\frac{T_e}{T_c}\right)^{1.25}\right]^{0.8}$$

Where, as defined in NEMA TR-27, page 29, part -5.

T_e = individual stabilized winding temperature rises measured immediately following the run with normal excitation on the core.

T_c = individual stabilized winding temperature rises measured immediately following full load current flowing in one (1) winding with the other winding short circuited.

$$t_2 = (234.5 + t_1)\left(\frac{R_2}{R_1}\right) - 234.5$$

$$R_3 = R_1\left[\frac{234.5 + t_3}{234.5 + t_1}\right]$$

vii) Determine X from volt-amperes and watts measured in step v as follows:

$$x = \frac{\sqrt{\left(\sqrt{3}VI_P\right)^2 - P^2}}{3I_p^2}\left(\frac{E_s}{E_p}\right)^2\left(\frac{ohms}{phase}\right)$$

viii) Calculate $I_p^2 R_2$ loss.

ix) Subtract $I_p^2 R_2$ from watts measured in (step v) to get stray losses at copper winding temperature t_2.

x) Calculate $I_p^2 R_3$ losses.

xi) Stray losses at t_3 =.

$$\frac{234.5 + t_2}{234.5 + t_3}\left(STRAY\ LOSSES\ AT\ t_2\right)$$

xii) Total watts loss for purpose of determining effective R will be $I_p^2 R_3$ + stray losses at t_3.

$$R\left(40^0 C\ AMBIENT\right) = \frac{TOTAL}{3I_p^2}\left(\frac{E_s}{E_p}\right)^2\left(\frac{ohms}{phase}\right)$$

ii. Bus duct and rectifier connected in line.

i) Rectifier inlet air maintained at 40 degrees Celsius.

ii) With rectifier dc output terminals short circuited, adjust rectifier output current to 107 percent I_d. Note temperatures and measure bus duct input watts "P", ac amperes “I_s”, ac volts “V”, dc amperes "I_d", and voltage across shorting strap "V_d".

iii) Calculate rectifier R as follows:

$$R = \frac{P - I_d(V_d + 2E_{TH})}{3I_s^2}$$

iv) Calculate X of bus duct and rectifier combined using measured values volt-ampere and input Watts (step ii above).

v) The X and R of package are respectively the sum of X and R of transformer, bus duct and rectifier.

c. Proposition III:

i. Transformer as in Proposition II.

ii. Bus duct alone.

i) With bus duct at ambient temperature between 15 degrees Celsius and 40 degrees Celsius adjust bus duct current for 100 percent, with its output shorted. Measure input watts, ac amperes, ac volts and note ambient temperature.

ii) Determine X of bus duct using measured values of volt amperes and input watts (step I above).

iii) Determine R of bus duct using measured input watts.

iii. Rectifier alone

i) With inlet air maintained at 40 degrees Celsius and rectifier dc output terminals shorted adjust rectifier output current to 107 percent "I_d".

ii) Measure input watts "P", ac amperes "I_s", ac volts "V", dc amperes "I_d", and voltage across shorting strap "V_d".

iii) Calculate rectifier R as follows:

$$R = \frac{P - I_d(V_d + 2E_{TH})}{3I_s^2}$$

iv) Determine X using measured values of volt-amperes and input watts (step ii above).

iv. The X and R of package are respectively the sum of X and R of transformer bus duct, and rectifier.

d. Definitions:

i. Where $E_{DO} = 1.35E_S$

ii. Where E_s = no load RMS voltage of transformer secondary measured line to line at transformer secondary terminals with transformer on rated tap and voltage E_p applied to primary terminals.

iii. Where E_{th} = voltage axis intercept of line drawn through two points on instantaneous forward voltage versus instantaneous forward current curve of the diode. The points chosen shall be 25 percent and 100 percent rated diode current with junction temperature at 50 degrees C.

$$Where\ \Delta\ E_x = \frac{3X_c I_d}{\lambda}$$

iv. Where X_c - Total ohms reactance of rectifier transformer plus interconnecting bus duct on a transformer secondary line to neutral base with transformer on rated tap. See Proposition I, II and III for determination.

v. Where I_d = Total current (average value) through load connected to rectifier.

vi. Where I_p = Line current (RMS) to transformer primary terminals on rated tap.

vii. Where E_p = Rated line-to-line RMS voltage of transformer primary at rated tap.

$$Where\ \Delta\ E_R = 21_d\ R_c$$

viii. Where R_c = Total ohms resistance of rectifier transformer plus rectifier plus interconnecting bus duct on a transformer secondary line to neutral base with transformer on rated tap.

ix. Where V_D = Voltage drop across rectifier dc output terminals shorting strap.

x. Where I_s = Current in bus duct. (RMS)

PART 3 DETAIL REQUIREMENTS FOR SURGE AND DESTRUCTIVE TEST ON DIODES

3.01 SURGE AND DESTRUCTIVE TEST ON DIODES

A. General

1. Prior to diode testing, the Contractor shall demonstrate that the test equipment to be used is capable of providing 10,000 amperes (minimum) over the rated forward surge current; that the test equipment is capable of providing sufficient power to destroy the diode, should the diode's limits be exceeded; and that the equipment can safely detect diode failure.

2. Three (3) sets of 10% or no less than five (5) diodes that have been subject to all in-line tests called for in this section of the Specification will be selected by CTA. These diodes will be removed from their heat tank assemblies for the test.

B. Surge Test On Diodes

1. The surge test shall be conducted as follows:

a. Out of the group of three (3) sets, one (1) set of five (5) diodes would be surge tested per NEMA-EIA Standard as follows:

i. One hundred applications of forward current equal to the non-repetitive surge forward current rating under the following conditions:

i) The rectifier diode is operating at its rated working peak reverse voltage, forward current and case temperature prior to surge.

ii) The rectifier diode is required to support its rated working peak reverse voltage during the surge and, following the surge, it must support the rated forward current specified in section 4.2.2.1 of ANSI EIA-282-A and non repetitive peak reverse voltage for one-half cycle and then working peak reverse voltage.

iii) Successive surges may not be applicable until the rectifier diode has returned to the operating conditions specified in section 4.2.2.1 of ANSI EIA-282-A.

iv) The one-half-cycle (1/120 of a second) surge forward current consists of a single-phase half-wave 60 Hertz sinusoidal pulse. The peak surge forward current consists of the peak of the half-wave pulse current flowing through the rectifier diode during the surge period. This is required JEDEC registration data (JESD282B.01).

v) The surge current four times greater than one cycle consists of a series of half-wave pulses for a specified period of time.

vi) Each diode failure will require complete retest of same amount additional diodes as initial test, selected by the CTA.

b. An acceptable diode failure is defined as a failure resulting from the failure of hydraulics on the diode test press, and electrical power surge resulting from some in-plant nominally outside of this testing, or an electrical power surge resulting from the Utility supply system. Human error or negligence toward the test procedure nor Mil. Spec. defined failures will not be an acceptable cause for a diode failure.

C. Destructive Test On Diodes

1. The destructive test on diodes shall be conducted as follows:

a. Repeat the surge test described above except the forward surge current application is increased by 3,000 amperes.

b. The surviving diodes shall be tested to destruction by increasing forward surge current applicable in 3,000 amperes increments applied as in step above, noting number surviving for each 3,000 ampere test series.

c. The Contractor shall supply and install at no extra charge to the Authority fifteen (15) identical replacements diodes in rectifier from which subject diodes were removed.

IN-LINE TESTS					
TEST DESCRIPTION	STANDARD	PASS/FAIL CRITERIA	ROUTINE	DESIGN	NOTES
Commutating Reactance and Resistance	CTA 34 21 12			XXXXX	Proposition I, II or III
100% Current Balance (N diodes)	IEEE Std. 1653.2	+/- 20% Max unbalance and diode junction temp < max value		XXXXX	@ 40 deg C ambient
150% Current Balance (N diodes)	IEEE Std. 1653.2 CTA 34 21 12	+/- 20% Max unbalance and diode junction temp < max value		XXXXX	@ 40 deg C ambient
100% Current Balance (N-1 diodes)	IEEE Std. 1653.2 CTA 34 21 12	+/- 20% Max unbalance and diode junction temp < max value		XXXXX	@ 40 deg C ambient

IN-LINE TESTS (continued)

TEST DESCRIPTION	STANDARD	PASS/FAIL CRITERIA	ROUTINE	DESIGN	NOTES
150% Current Balance (N-1 diodes)	IEEE Std. 1653.2 CTA 34 21 12	+/- 20% Max unbalance and diode junction temp < max value		XXXXX	@ 40 deg C ambient
Efficiency	CTA 34 21 12	> 97.5%		XXXXX	@ 40 deg C ambient
Displacement Power Factor	CTA 34 21 12	>90% lagging		XXXXX	@ 40 deg C ambient
Voltage Regulation	CTA 34 21 12	Per CTA 16606		XXXXX	@ 40 deg C ambient
100% Rated Full Load Current Temperature Rise	CTA 34 21 12	No specified value		XXXXX	@ 40 deg C ambient Used as a baseline for determining stability

IN-LINE TESTS (continued)					
TEST DESCRIPTION	STANDARD	PASS/FAIL CRITERIA	ROUTINE	DESIGN	NOTES
150% Temperature Rise	CTA 34 21 12	No specified Value		XXXXX	@ 40 deg C ambient
RI-9 Overload Test	CTA 34 21 12	No electrical failures and no temperatures above max allowable values		XXXXX	@ 40 deg C ambient
Short Circuit Test	CTA 34 21 12	No physical damage, electrical failures, fuse opening or unintentional opening of a device.		XXXXX	Immediately following RI-9 test
Harmonic Analysis	IEEE Std. 519			XXXXX	
Transient Voltage Surge Test		< 75% of diode withstand rating		XXXXX	

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 General and Special Conditions and Division 01 Specification sections, apply to this section.

1.02 SUMMARY

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 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 USED

END OF SECTION

SECTION 34 21 19
TRACTION POWER 15 KV AC SWITCHGEAR

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Special conditions and Division 01 Specification sections, apply to this section.

1.02 SUMMARY

A. This section covers the detail requirements for designing, manufacturing, testing, delivering, installing and commissioning the 15kv ac switchgear line-ups for the Authority's Traction Power Substations.

B. Each switchgear line-up shall be metal-clad, draw-out type for 12,600 volt, 3 phase 60 HZ ac grounded neutral.

C. Incoming service for the switchgear will be provided directly from ComEd Company 12,600 volt ac feeders and will serve as the supply for the rectifier transformers, and auxiliary power transformers. There will be two incoming lines from ComEd for each substation as shown on the Contract Drawings. There will be a tie breaker in between the two incoming line breakers. In normal operation, out of two incoming line breakers and a tie breaker, only two breakers will be closed at a time. If one of the breakers is tripped the third breaker will close automatically through auto transfer scheme.

D. Switchgear shall comply with the latest applicable standards of ANSI C37.20.2, IEEE, NEMA SG4 and SG5. AC breakers and switchgear shall comply with UL File #146558.

E. 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 03, Rectifier Transformer.
3. Section 34 21 04, Traction Power 600 Volt DC Silicon Rectifier.
4. Section 34 21 09, Traction Power Support.
5. Section 34 21 10, Traction Power Equipment Installation.
6. Section 34 21 11, Traction Power Equipment Testing.

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 SEQUENCE OF OPERATION

A. UNDER VOLTAGE DETECTION

1. Each 152 breaker shall have two sets of potential transformers, one set on the line (Utility) side and one set on the load (Bus) side. Under voltage shall be detected by the SEL-451 relay on the line side by the 27L device and on the bus side by the 27B device. Upon detection of an under voltage condition, time delays shall be incorporated with the time delay of the 27L set longer than the time delay of the 27B. The time delay for the 27L should be approximately 10 (ten) seconds and the time delay for the 27B should be approximately 5 (five) seconds. The 124 tie breaker will not have under voltage detection.

2. Under voltage detected on the line side by the 27L1 or 27L2 device shall open the corresponding 152 breaker.

3. Under voltage detected on the bus side by the 27B1 or 27B2 device shall take all rectifiers being supplied by the corresponding bus off line.

4. Detection of an under voltage condition shall result in a rectifier conditional lockout and will not require manually resetting any device. When the under voltage condition no longer exists, any rectifier that was taken off line will be able to be closed though local control or via SCADA.

5. Loss of voltage on either of the incoming lines will cause an automatic transfer to the other line provided it is not in a fault/tripped condition. Retransfer to the original line will not be automatic.

B. AUTO TRANSFER SEQUENCE OF OPERATION

1. The following 4 (four) conditions shall be incorporated into the Auto Transfer Sequence of Operation. If a fault condition exits on either 152 Line Breakers, the Sequence shall be disabled

a. CONDITION I: LINE BREAKER 152-1 CLOSED AND 124 BUS TIE BREAKER CLOSED AND LINE BREAKER 152-2 OPEN

i. Under voltage is detected by the SEL-451-1 27L1, SEL-451-1 27B1, and the SEL-451-2 27B2
ii. After a five second delay, the SEL-451-1 27B1 shall take all rectifiers connected to Bus 1 off line and the SEL-451-2 27B2 shall take all rectifiers connected to Bus 2 off line
iii. After a ten second delay, Line Breaker 152-1 shall open and Line Breaker 152-2 shall close
iv. The 124 Bus Tie Breaker will remain closed
v. All rectifiers connected to Bus 1 and Bus 2 can be returned to service

b. CONDITION II: LINE BREAKER 152-2 CLOSED AND 124 BUS TIE BREAKER CLOSED AND LINE BREAKER 152-1 OPEN

i. Under voltage is detected by the SEL-451-2 27L2, SEL-451-2 27B2 and the SEL-451-1 27B1
ii. After a five second delay, the SEL-451-2 27B2 shall take all rectifiers connected to Bus 2 off line and the SEL-451-1 27B1 shall take all rectifiers connected to us 1 off line
iii. After a ten second delay, Line Breaker 152-2 shall open and Line Breaker 152-1 shall close
iv. The 124 Bus Tie Breaker will remain closed
v. All rectifiers connected to Bus 2 and Bus 1 can be returned to service

c. CONDITION III: LINE BREAKER 152-1 CLOSED-124 BUS TIE BREAKER OPEN-LINE BREAKER 152-2 CLOSED

i. Under voltage is detected by the SEL-451-1 27L1 device and the SEL-451-1 27B1
ii. After a five second delay, the SEL-451-1 27B1 shall take all rectifiers connected to Bus 1 off line
iii. After a ten second delay, Line Breaker 152-1 shall open and Bus Tie Breaker 124 shall close
iv. All rectifiers connected to Bus 1 can be returned to service

d. CONDITION IV: LINE BREAKER 152-1 CLOSED-124 BUS TIE BREAKER OPEN-LINE BREAKER 152-2 CLOSED

i. Under voltage is detected by the SEL-451-2 27L2 device and the SEL-451-2 27B2
ii. After a five second delay, the SEL-451-2 27B2 shall take all rectifiers connected to Bus 2 off line
iii. After a ten second delay, Line Breaker 152-2 shall open and Bus Tie Breaker 124 shall close
iv. All rectifiers connected to Bus 2 can be returned to service

C. BUS-TIE BREAKER BUS 1 OVERCURRENT RELAY (Bus 2 Relay similar)

1. Detection of an overcurrent condition by a partial bus differential relay (device 551-1) located in the bus-tie (device 124) cubical shall cause the bus tie breaker and the respective line breaker (device 152-1) to trip open. It shall also operate the close inhibit relay (device 151-1X) which shall inhibit the closing of the bus-tie and respective line breaker. The close inhibit function associated with each partial bus differential relay(s) shall be performed via a hand reset electro-mechanical type 86 lockout relay mounted on the bus tie cubical, one for each bus.

2. Detection of a bus-tie 551-1 relay failure shall release a normally closed/held open contact in the trip circuit used to open the 124 bus-tie breaker.

3. Detection of a relay failure or a trip circuit failure shall release a normally open/held closed 551-1 contact used to report the condition to SCADA.

D. LINE 1 BREAKER RELAY (Line 2 Relay similar)

1. Detection of an overcurrent condition by an incoming line breaker relay (device 451-1) shall cause the line breaker (device 152-1) to trip open. It shall also inhibit the closing of the 152-1 line breaker by releasing a normally open/held closed contact in the line overcurrent relay (451-1) in the 152-1 line breaker close circuit.

2. Detection of a line overcurrent 451-1 relay failure shall release a normally closed/held open contact in the trip circuit used to open the 152-1 line breaker.

3. Detection of a relay failure or a trip circuit failure shall release a normally open/held closed 451-1 contact used to report the condition to SCADA.

E. RECTIFIER 1 TRANSFORMER OVERCURRENT RELAY (remaining Rectifier Transformer Relays similar)

1. Detection of an overcurrent condition by the rectifier transformer overcurrent relay (device 551-T1) relay shall cause the rectifier transformer breaker (device 52-1) to trip open. It shall also operate the rectifier electro-mechanical lockout relay (device 86-1) relay via the rectifier annunciator (device 30) which will require a manual hand reset prior to closing the 52-1 rectifier transformer breaker.

2. Detection of a rectifier transformer overcurrent 551-T1 relay failure shall release a normally closed/held open contact in the trip circuit used to open the 52-1 rectifier transformer breaker.

3. Detection of a relay failure or a trip circuit failure shall release a normally open/held closed 551-T1 contact used to report the condition to SCADA.

2.02 TECHNICAL REQUIREMENTS

A. The 15kV ac switchgear assembly shall be rated as follows:

Nominal Voltage	12.6kV
Maximum Voltage	15kV
Frequency	60Hz
Insulation Level	
60 Hertz withstand	36kV
Insulation Level	
Impulse withstand	95kV
Main Bus Continuous	
Current	1200amp

B. Circuit breakers shall be 15kV class, vacuum break, single deck, draw-out type having a nominal interrupting capacity of 500,000kVA and close and latch rating of 37,000 amperes, symmetrical. Operating mechanisms shall be of the stored energy type and shall be suitable for operation from the 125 volt dc battery and shall be electrically and mechanically trip free. All circuit breakers shall be mechanically and electrically interchangeable. A four (4) digit mechanical register type operations counter shall be mounted on each removable element. Circuit breaker shall be designed to roll directly from the floor into the switchgear or from the switchgear compartment onto the floor without a need for external lifting device or dolly. Circuit breaker shall be supplied with two swivel type wheels on the front and two fixed wheels on the rear.

C. Interrupters, operating mechanisms and equipment cubicles must be designed, tested and assembled by one manufacturer. The manufacturer shall submit an experience and reliability list demonstrating at least five (5) years of successful in service performance of vacuum switchgear. The manufacturer shall also perform all ANSI tests, including dielectric, momentary withstand and short circuit, with the breaker in the equipment cubicle.

D. The breaker shall be provided with a contact erosion indicator which is not influenced by mechanism wear and does not require mathematical calculations to determine the amount of contact erosion.

E. Each circuit breaker cubicle shall be provided with protective shutters which are forced to close and cover live high voltage terminals as the breaker is racked out of the cubicle. Suitable interlocks shall be provided to prevent the insertion or removal of a breaker element in the "closed" position. The switchgear shall have the capability of racking the breakers with the door shut.

F. Each circuit breaker shall be provided with manual CLOSE and TRIP recessed button on the door of the breaker cubicle. Manual CLOSE button shall be covered with Plexiglas to avoid accidental closing.

G. A motorized remote racking device shall be provided for each switchgear lineup at each substation. The racking device shall be capable of remotely rack any draw out,15 kV circuit breaker and any auxiliary drawer in the switchgear line up. A 125 volt dc receptacle shall be installed on the door of each auxiliary transformer cubicle to supply power to the racking device. The device shall be similar to Eaton’s motorized racking device, type MR2 or ABB Smart Rack Electric Remote Racking device.

H. Buses shall be insulated copper bar, rated 1200 ampere capacity at 40 degrees C and shall be supported, and braced to withstand short circuit stresses at least as great as those for which the circuit breakers are designed. The contact surfaces of bolted joints in the buses and main connections shall be silver-plated for copper, nickel-plated for aluminum. Removable boots shall be furnished for all joints. The bus insulation shall be flame retardant track resistant epoxy, heat-shrink; PVC insulation will be not acceptable.

I. Positive-acting mechanical interlocks shall be provided so that a breaker in the closed position cannot be disconnected from or connected to the bus. A ground bus shall be provided to engage the circuit breakers in both operate and test positions. The ground bus shall be installed through all switchgear cubicles, including breaker, auxiliary transformer and metering cubicles.

J. Current and potential transformers shall have mechanical strength and thermal rating commensurate with rating of associated equipment.

K. The switchgear shall be arranged for top and bottom entrance for all incoming power circuits. Cable lugs shall be provided for all power cables. The Contractor shall provide cable supports, such that all power cables will be fully supported, and the cable terminations would not be exposed to the cable weight. The insulated mounting for terminals shall be provided in rectifier and incoming line compartments to prevent circulation of current between cable and ac switchgear structure. The Contractor shall also provide suitable insulating material and tape to properly insulate, for 15 kV service, all exposed current carrying members of the terminators and bus connections. Information concerning cable sizes, construction and terminations required will be provided at a later date. It shall be the responsibility of the Contractor to notify ComEd and CTA 60 days in advance of the time this information is required.

L. Relaying current and potential transformer secondary leads shall be wired to terminal blocks for possible future insertion of remote metering. The current leads to these terminal blocks shall be jumpered as required. Shorting type terminal blocks shall be provided for all current transformer secondary leads. No sliding contacts will be permitted on potential transformer secondary wiring.

M. Relaying potential transformers shall have primary fuses and shall be mounted on draw-out or tilt-out carriages. Guides for both shall be structurally sound to prevent excessive vertical and horizontal play to assure reliable positive connection. The front of the carriage shall extend up to close the section when the transformer is in the operating position. Primary contacts for the draw-out feature shall be designed to maintain proper contact pressure.

Structurally reliable, visible grounding devices shall be provided to make certain that the draw-out carriage mounted potential transformer primary terminals are grounded when the carriage is withdrawn. Compartments housing the relaying potential transformers may be located above incoming line breaker cubicle.

N. Compartments housing current transformers for remote ComEd Company metering shall have hinged door and hasp for padlock seal by others. A terminal block for terminating both metering current and potential transformer secondary wiring shall be mounted inside of each line current transformer compartment in a readily accessible position. No other wires shall be on this block, and no other blocks shall be in this compartment. Wiring from current transformer to terminal block will be furnished and installed by others in the field. 12kV distribution class surge arresters shall be provided inside metering compartment and ground side connector accessible for removal, when required.

O. Separate compartments housing potential transformers for remote ComEd Company metering shall have hasp for padlock seal by others. Internal conduit system shall be provided to terminal connection block in compartment housing for complete isolation of metering potential transformer secondary wiring which will be furnished and installed by others in the field. Primary connection for the potential transformer shall be made on the supply side of the current transformer. Potential transformers may be mounted in any one of the three following ways:

1. On draw-out carriage without sliding secondary contacts.

2. Fixed, horizontal with draw-out fuses.

3. Fixed, vertical with clearance for easy fuse removal.

P. All interior and exterior hinged compartment doors shall include a hasp that can accept a padlock.

Q. Secondary and control wiring in each unit, including that on removable element, shall be ICEA Standard Type GRY SIS No. 12 AWG or larger, stranded switchboard wire, insulated for 600 volts ac service unless otherwise noted and shall be factory-wired to screw-type terminal blocks for top connection to external conductors. Terminal blocks shall be General Electric Company Type EB-5, Marathon Series 1500, or approved equal.

R. Compression type solderless copper lugs shall be furnished for each terminal block, for external control and instrumentation wires. All control wires shall be terminated utilizing insulated ring type connectors: Burndy Cat. No. YAEV10-L-36, T&B Cat. No. C1 insulated, or approved equal.

S. Cable markers shall be as specified in Section “General Requirements for Traction Power Equipment”, Paragraph 1.3.F.4.

T. The Manufacturer to provide fuse in trip circuits compatible to maximum possible tripping circuits.

U. Assembled control equipment and wiring shall be subjected to a one minute test of 3000V ac phase to ground at factory in accordance with ANSI C37.205.3.4.2.

V. Breaker auxiliary switches, whether cell mounted or mounted on removable element, shall be made up and operable when breaker is withdrawn to test position.

W. Solid state protective relays shall be semi-flush mounted cases with test switches and dust - tight covers. Test switches shall be ABB flexitest switch type FT-1, or approved equal.

X. 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 CTA's approval prior to painting the equipment. One (1) quart of matching touch up paint shall be furnished for each assembly.

Y. All full height hinged doors shall be provided with a minimum of three latches, securely fastened in the closed position, and easily opened without the use of tools. For doors less than full height of the equipment, a minimum of two latches will be acceptable. Doors shall be provided with stops to hold them securely in the open position in a manner to allow the opening of the doors of adjacent cubicles.

Z. All circuit breakers shall have two handles in front for ease in moving the breaker.

AA. The rear and front closure of the compartments shall be hinged and lockable with a padlock.

BB. A red laminate plastic tag of the type specified in Section 34 21 01, Paragraph 1. 03. E.11, of these Specifications shall be mounted on the front and rear doors of each compartment stating "DANGER 12,600 volts" in bold letters 1-1/2 inch high. Additionally, all warning signs required by NFPA-70E shall be installed.

CC. An engraved plastic laminated tag with white background and 1 inch high red lettering labeled "DANGER-DO NOT OPEN" as well as warning signs as required per NFPA-70E shall be installed on each shutter.

DD. All devices such as fuses, switches, terminal blocks, etc. shall be mounted no further than 18 inches of the face of the cubicle and easily accessible for operations and maintenance.

EE. Shipping splits shall be arranged so that the sections will be easily jointed in the field.

FF. Test cabinet shall be provided complete with open and close pistol grip, switch, indicating lights, devices, terminals for connecting control power, and a multi-conductor control cable 8 feet long complete with receptacle matching the plug on the removable breaker unit. The test cabinet shall be NEMA Type 12 construction, ANSI-61 paint finish and shall be suitable for wall mounting complete with lugs and 1-1/2 inch top and bottom entry conduit hub.

GG. One (1) grounding cable clamp set (grounding cluster) shall be furnished for each substation. It shall be similar to Chance Cat. #C6000758 except it shall have #4/0 cables and cluster length shall be sufficient to reach between phase and ground studs.

2.03 DETAIL EQUIPMENT

A. Each 15 kV switchgear line-up shall include assorted switchgear positions and switchgear appurtenances of each of the various types listed below, and shall be incorporated into one continuous enclosure made up of compartments as required.

B. Detail of each type of equipment shall be in accordance with the following:

1. Item 1: Each 12,600 volt ac position for ComEd Company metering shall include:

a. One (1) metal clad stationary unit with 1200 ampere insulated bus.

b. Three (3) General Electric Company, Type JKM-5 CT's Catalog No.631X20, 400-5 ampere for remote ComEd Company metering.

i. ComEd Company will ship the metering CT's to the rectification equipment manufacturer at the Contractor's expense upon receipt of detailed shipping instructions. The Contractor shall provide space, mounting brackets, primary wiring and terminal blocks; and make factory installation of this equipment. The Contractor should refer to the ComEd Co. Metering Department Guide.

c. Two (2) General Electric Company, Type JVM-5 PT's Catalog No. 685X43, 7200-120 volt for remote ComEd Company metering.

i. ComEd Company will ship the metering PT's to the rectification equipment manufacturer at the Contractor's expense upon receipt of detailed shipping instructions. The Contractor shall provide space, mounting brackets, primary wiring and terminal blocks; and make factory installation of this equipment. Draw-out fuse assembly for PT's (if provided) shall be complete with clips for two (2) General Electric Company Catalog No. 6293011G-20 or approved equal potential fuses. The Contractor should refer to the ComEd Co. Metering Department Guide.

d. Four (4) ComEd approved Insulated grounding studs with suitable (15 kV) insulated caps for ComEd Company use in grounding phasing lines and ground bus. Locate one (1) in each phase leg above cable terminators on line side of CT's and one on the ground bus. Studs shall be 5/8 inch diameter and protrude at least 3 inch beyond insulation. Caps may be porcelain, molded bake-lite, or equivalent. The caps shall fully cover the exposed portion of the studs and shall be removable by hand.

e. Single lines, schematics and drawings showing equipment layout must be provided by the Contractor to ComEd Engineering and Metering Department for their approval.

f. Three (3) distribution class 9 kV surge arresters, connected to each phase leg above cable terminators on the line side of CT'S.

g. One (1) set of space heaters.

h. A hand tool removable safety screen shall be provided behind the rear door.

2. Item 2: Each 12,600 volt ac incoming line position for ComEd Company shall include; but shall not be limited to:

a. One (1) metal-clad stationary unit with 1200 ampere insulated bus.

b. One (1) insulated 1200 ampere 15 kV class vacuum circuit breaker removable element with 8-stage auxiliary switch. (Device 152).

c. Six (6) line relaying current transformers 600-5 Amperes, ANSI accuracy Class C100.

d. Two sets of three (3) relaying PT's, draw out type with current limiting fuses, 12,000 - 120 volt, 200 VA, ANSI accuracy class 1.2, may be located in super structure compartment; One set connected grounded wye primary to main bus; And the other set connected grounded wye primary to the line side of the breaker. One (1) microprocessor based solid state ground directional overcurrent relay with eight outputs and seven inputs, conventional terminal blocks, plus one additional conventional terminal block (4 U) with 13 standard

Form A and 2 standard Form C outputs and 8 independent inputs. Horizontal panel flush mounted, 125 volt dc power supply, wye connected secondary input voltage, five ampere phase and five ampere secondary input current, 125 volt dc control input voltage and standard communication protocol. Schweitzer SEL - 451, or approved equal, for ComEd Line protection (Device 50, 51 and 27) .

e. Flextest switches, ABB type FT-1 or approved equal for switchboard mounting to be used with relay Schweitzer SEL-451-5. Quantity as needed for the control and relay circuits.

f. Each output contact of the SEL relay whether it is used or spare shall be wired to a potential pole of the test switch. All spare contacts in series with the potential pole shall be terminated at the terminal blocks for the future use.

g. One (1) electrically operated self reset, 125 volt dc auxiliary relay, similar to GE type HGA or approved equal to provide permissive close interlock scheme (Device 3).

h. One (1) three phase voltage transducer, 3 elements, 120 volt nominal input potential, input voltage range 0-150 volts, output at full scale 0-1mA dc, accuracy at 25°c + 0.25%, TransData type 30PS501.

i. One (1) three phase current transducer, 3 elements, 5 ampere nominal input current, input current range 0-7.5 amperes, output at full scale 0-1mA dc, accuracy at 25°c + 0.25%, TransData type 30CS501.

j. One (1) AC indicating ammeter, 0-600 ampere scale.

k. One (1) AC ammeter switch, 3-phase, with "OFF" position.

l. Tw0 (2)) AC voltmeters, 0-15 kV. Single Phase monitoring phase to phase.

m. Two (2) AC voltmeter switches, 3 phase with "OFF" position.

n. One (1) removable element position switch with required (minimum of six) interchangeable stages.

o. One (1) permissive control switch (REMOTE-LOCAL), REMOTE position 12 o'clock and LOCAL clockwise (Device 169).

p. One (1) control switch with red and green indicating lamps, CLOSE- right - TRIP- left (Device CS).

q. One (1) white indicating lamp to indicate the control circuit voltage is available.

r. Terminal lugs for 3-1/c-500 kcmil, copper 15 kV EPR insulated, shielded, PVC jacketed cable.

s. One (1) set of space heaters.

t. Provide contacts as required wired to terminal blocks for use with auxiliary, control and SCADA circuits.

3. Item 3: Each 12,600 volt ac bus tie position shall include:

a. One (1) metal clad stationary unit with 1200 Ampere insulated bus and 1200 ampere insulated tap.

b. One (1) 1200 Ampere 15 kV class vacuum circuit breaker removable element with 8 stage auxiliary switch.

c. Six (6) line relaying CT's 600-5 ampere, ANSI, accuracy class C100.

d. Two (2) microprocessor based solid state overcurrent relay with 5 outputs and 2 inputs, conventional terminal blocks, horizontal panel flush mounted, two high units, 125 volt dc control input voltage, 5 ampere phase and 5 ampere secondary input voltage, EIA 232 port and standard communication protocol, Schweitzer SEL-551, or approved equal, for bus protection (Device 151 and 151N).

e. Flexitest switches, ABB type FT-1 or approved equal for switchboard mounting to be used with relay Schweitzer SEL-551. Quantity as needed for control and relay circuits.

f. Each output contact of the SEL relay whether it is used or spare shall be wired to a potential pole of the test switch. All spare contacts connected in series with potential pole shall be terminated at the terminal blocks for the future use

g. One (1) electrically operated self reset, 125 volt dc auxiliary relay, similar to GE type HGA or approved equal to provide permissive close interlock scheme (Device 3).

h. Two (2) 125 volt dc high speed manual reset relays similar to Electroswitch type LOR or approved equal for means to reset the breaker manually after it is tripped and to provide permissive circuits for the associated line breaker and the tie breaker (device 151-1x and 151-2x).

i. One (1) removable element position switch with required (minimum of six) interchangeable stages.

j. One (1) permissive control switch REMOTE-LOCAL, REMOTE position 12 o'clock, LOCAL clockwise (Device l69).

k. One (1) control switch with red and green indicating lamps CLOSE right - TRIP left (Device CS).

l. One (1) selector switch (AUTOCLOSE-OFF) used in auto close circuit for the line and tie breakers (Device 143).

m. One (1) white indicating light to indicate the control circuit voltage is available.

n. One (1) set of space heaters.

o. Provide contacts as required wired to terminal blocks for use with the auxiliary, control and SCADA circuits.

p. One (1) 125 volt sub dc distribution panel with eight (8), 2-pole 30 ampere circuit breakers. A separate circuit shall be provided in a sealed trough from this panel to each cubicle for control, tripping metering and relay circuits of the breaker, per Article 1.03E of Section 34 21 01.

4. Item 4: Each 12,600 volt ac position for the rectifier transformers shall include:

a. One (1) metal-clad stationary unit with 1200 ampere insulated bus.

b. One (1) insulated 1200 ampere, 15 kV class vacuum circuit breaker removable element with 8-stage auxiliary switch.

c. Three (3) rectifier relaying current transformers 300-5 ampere ANSI accuracy Class C100.

d. One (1) microprocessor based solid state overcurrent relay with 5 outputs and 2 inputs, conventional terminal blocks, horizontal panel flush mounted, two high units, 125 volt dc control input voltage, 5 ampere phase and 5 ampere secondary input voltage, EIA 232 port and standard communication protocol, Schweitzer SEL-551 or approved equal for rectifier transformer protection.

e. Flexitest switches, ABB type FT-1 or approved equal for switchboard mounting to be used with relay Schweitzer SEL-551. Quantity as needed for control and relay circuits.

f. Each output contact of the SEL relay whether it is used or spare shall be wired to a potential pole of the test switch. All spare contacts connected in series with the potential pole shall be terminated at the terminal blocks for the future use

g. One (1) removable element position switch with required (minimum of six) interchangeable stages.

h. One (1) permissive control switch (REMOTE-LOCAL), REMOTE position at 12 o'clock and LOCAL clockwise. (Device 69).

i. One (1) control switch with red and green indicating lamps, CLOSE-right - TRIP-left (Device CS).

j. One (1) ac indicating ammeter, 0-300 Ampere scale.

k. One (1) ac ammeter switch, 3-phase, with "OFF" POSITION.

l. Terminal lugs for 3-1/c #2/0 AWG Copper, 15 kV EPR insulated, shielded PVC jacketed cable, and bolted connections to copper bus bars with flexible bus braids shall be provided as needed for the cubicles.

m. One (1) set of space heaters.

n. Provide contacts as required wired to terminal blocks for use with the auxiliary, control and SCADA circuits.

5. Item 5: Each 12,600 volt ac position for auxiliary power transformers shall include:

a. One (1) metal clad stationary unit with 1200 ampere insulated bus.

b. One (1), 3 pole fused draw out assembly with current limiting fuses for supplying auxiliary power transformers described below. Guides for draw-out assembly shall be structurally sound to prevent excessive vertical and horizontal play to assure reliable positive connection. Each assembly to be complete with key or structurally reliable mechanical interlock system arranged such that associated transformer low voltage circuit breaker described below must be open before assembly can be moved to either operate or withdrawn position.

c. One (1) auxiliary power transformer 75 kVA 3-phase 12,600V, 60 Hz primary with five full capacity no load taps consisting of 3-2 ½ percent above and 2-2 1/2 percent below the nominal 12,600 Volts or as otherwise specified at design conference, full capacity taps and 3-phase, 4-wire, 120/208V secondary. The taps shall be accessible from the front of the cu

d. Transformer shall be 80 degrees C rise, dry type or epoxy cast, self-cooled, with copper windings. Transformer shall be delta primary - wye secondary with 30-degrees phase shift. Transformer winding insulation shall be Class 220 for dry type and class 185 for epoxy cast. The auxiliary transformer compartment shall be complete with a Kirk Key or structurally reliable mechanical interlock systems arranged such that the associated low voltage circuit breaker must be open and the associated 15kV fuse draw-out assembly must be in the draw-out disconnected position, before personnel can gain access to the auxiliary transformer.

e. Transformer high voltage insulation class shall be 15kV with BIL of 95 kV or more and low voltage winding shall have 30kV BIL.

f. The transformer shall have screened access plus vented door for air circulation (vent at top and bottom).

g. The transformer shall be able to be removed via access doors/panels without disassembling any bus work.

h. One (1) manually operated molded case air circuit breaker, 3-pole, 600 volt ac, K frame with 400 ampere thermal adjustable magnetic trips set at 250 amperes. Breaker shall be complete with a kirk key or structurally reliable mechanical interlock system arranged so that the breaker must be open before associated fuse assembly described above can be moved to either the operated or withdrawn position. Terminal lugs shall be provided for 4-1/C-350kcmil, copper, 600 volt, insulated cable.

6. Item 6: A test cabinet complete with accessories shall be provided as described in Paragraph 1.2CC of this section.

7. Item 7: Accessories for handling, removable components in the switchgear assembly. These shall include tools for removing and inserting vacuum bottle, breaker racking-in crank, maintenance closing device, forklift type breaker handling dolly (or wheeled removable element), and/or other devices as required. All accessories shall be designed for reasonable handling of removable components by one person of average strength. Two (2) racking handles and two (2) maintenance closing devices shall be furnished for each of the three substations.

8. Item 8: Each channel base assembly drilled to accept stationary units. These shall be shipped in advance of switchgear.

9. Item 9: Each 1200 ampere 15 kV class vacuum circuit breaker element shall be identical and interchangeable. One (1) spare 15 kV class vacuum circuit breaker element shall be supplied at Broadway Substation.

2.04 QUANTITY OF EQUIPMENT REQUIRED

A. Each of the items shall be furnished and delivered to Substation Site as listed below. Each type of equipment shall be equipped as detailed in Paragraph 1.3 of this Section. Equipment shall be arranged in integral assemblies as shown on the Contract Drawings, for each of the Substation as follows:

1. AT BROADWAY SUBSTATION

a. Item 1: Two (2), 12,600 volt ac positions for ComEd Company metering incoming lines.

b. Item 2: Two (2), 12,600 volt ac positions for ComEd Company incoming line breakers.

c. Item 3: One (1), 12,600 volt ac position bus tie breaker.

d. Item 4: Two (2) 12,600 volt ac positions for rectifier transformer breakers.

e. Item 5: Two (2), 12,600 volt ac positions for 3 pole fused draw out assemblies with current limiting fuses for self-contained auxiliary power transformers.

f. Item 6: One (1) test cabinet and One (1) Remote Racking Device.

g. Item 7: One (1) set of Accessories.

h. Item 8: One (1) set of channel base assembly.

i. Item 9: One (1) spare 1200 ampere 15 kV class vacuum circuit breaker element. The breaker element shall not be incorporated into the ac switchgear lineup but shall be furnished loose.

2.05 CERTIFICATION OF RATINGS

A. The manufacturer must furnish certified evidence of prior tests that the proposed switchgear meets these specifications. In the absence of such test data, the CTA reserves the right to require a factory test demonstration of said equipment.

PART 3 EXECUTION

3.01 INSTALLATION

A. See Section “Traction power equipment installation” for the ac switchgear installation requirements.

3.02 TESTING

A. See Section “Traction Power Equipment Testing” for the ac switchgear testing requirements.

3.03 SUPPORT EQUIPMENT

A. See Section “Traction Power Support” for the ac switchgear support equipment requirements.

END OF SECTION

SECTION 34 21 25
TRACTION POWER CABLES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Special Conditions and Division 01 Specification sections, apply to this section.

1.02 SUMMARY

A. This section specifies the requirements for providing 500, 929, 1, 000, 1,111, 1,500, and 2,000kcmil 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: The following sections contain requirements that relate to this section:

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 8-14Specification for Concentric Lay Stranded Copper Conductors
2. ASTM Standard D 470-13Test Methods for Cross Linked Insulations and Jackets for Wire and Cable

3. ASTM Standard D 471-12aTest 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 2802-14Specification for Ozone-Resistant Ethylene-Alkene Polymer Insulation for Wire and Cable

7. ASTM Standard D 2863-13Test Method for Measuring the Minimum Oxygen Concentration for Candle Like Combustion of Plastics

8. ASTM Standard E 662-15Test 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-95-658-2009Standard 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-96-658for 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.

G. The insulation shall be circular in cross-section and concentric to the conductor. The minimum thickness at any point shall not be less than 90% of the specified thickness called for in 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 90^{o} 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. Splices are not allowed except in manholes or in accessible areas with prior approval by the Authority.

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 include~~s~~ 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 ne 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 in contract 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 150º +/- 2 Celsius Sample shall be from completed cable.
Tensile Strength after 168 hours at 121º 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 water tank on selected completed reels of cable after 6 hours of immersion and while still immersed

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	ICEA S-96-659, Table 4-5	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
K Constant for Insulation Resistance	ICEA S-68-516, Table 3.1		
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	
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.	

Requirement/Test	Applicable Standard	Requirement	Additional Requirement
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.	

Requirement/Test	Applicable Standard	Requirement	Additional Requirement
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
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.	

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 Contract, including General and Special Conditions and Division 1 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 not 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:

i. 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.

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 Contract, including general and Special Conditions and Division 1 Specification section, 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:

1. Section 34 21 65, Traction Power Basic Electrical Materials and Methods

2. 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:

i. With the line connected to the blade side and the load connected to one set of clips.
ii. With the line connected to the blade side and the load connected to the second set of clips.

iii. With the load connected to the blade side and the line connected to one set of clips.

iv. 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. Yard 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.

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 other 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:

B. Detailed shop construction drawings of each size and type of enclosure to be supplied.

C. Shop drawings for structural steel fabrication.

D. All manufacturers' literature including physical and chemical properties and test results for paint materials.

E. 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.

    1. Tests conducted using alternating current power source will not be acceptable.

L. 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.

M. 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.

N. 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.

O. 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.

H. 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.

END OF SECTION

SECTION 34 21 43
TRACTION POWER DOOR LIMIT SWITCHES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. The Contract Drawings and general provisions of the Contract, including General and Special Conditions and Division 1 Specification sections, apply to this section.

1.02 SUMMARY

A. This Section specifies all door limit switches required for traction power substations.

B. Related Sections:

1. Section 34 21 01 General Provisions for Traction power

2. Section 34 21 90 Traction Power Substation Controls

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. Submit all data necessary to evaluate 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.

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 DOOR LIMIT SWITCHES

A. The Contractor shall furnish and install security alarm door limit switches at each door for supervisory monitoring of open door alarms. The substation doors for personnel are single leaf single swing, and for equipment are overhead coiling doors.

B. Door limit switches shall be heavy duty, oil and dust proof and watertight units, double pole; single throw (DPST) rated 10 amperes ac or dc continuous, and not less than 250 mA inductive break current at 125 volt dc.

C. Door limit switches shall be front operated, normally open contact, vane operated limit switches without indicating lights; or magnetically operated switches similar to Sentrol 1045T Series or approved equal.

PART 3 EXECUTION

3.01 GENERAL INSTALLATION

A. The Contractor shall design limit switch mounting plates, and provide door hardware required to operate the limit switch when the door swings open or when the door rolls up to open. When doors are closed, the limit switch contact shall be closed. When a door opens, its limit switch contact shall open and provide a substation security indication to the supervisory system.

B. Door limit switches at the substation shall be wired in series with each other and with attended/unattended control selector switch open in ATTENDED position. This security circuit shall be connected to a terminal point in supervisory control cabinet.

C. The number and location of door limit switches are shown on the Contract Drawings.

D. Installation shall be complete with supports, junction boxes with terminal blocks, conduit, wire and associated specialties as may be required to complete the security system in a workman like manner.

E. An "ATTENDED - UNATTENDED" selector switch shall be as specified in Section Traction power substation Controls.

END OF SECTION

SECTION 34 21 44
SUBSTATION MISCELLANEOUS STRUCTURAL STEEL

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and General provisions of Contract, including General and Special Conditions and Division 01 Specification sections, apply to this section.

1.02 SUMMARY

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 Specification 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.

END OF SECTION

SECTION 34 21 45
SUBSTATION TIMBER

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and 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.

C. Related Sections: The following section contains requirements that relates to this section.

1. Section 34 21 41 – D.C. Disconnect knife Switch Enclosures.

1.03 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 USED

END OF SECTION

SECTION 34 21 46
TRACTION POWER CABLE LUGS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of Contract and 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.

D. Related Sections: the following sections contain requirements that relates to this section.

1. Section 34 21 61, General Provisions Traction Power
2. Section 34 21 65, Basic Electrical Materials and Methods
3. Section 34 24 23, Contact Rail Bonding
4. Section 34 21 25, Traction Power Cable
5. Section 34 21 40DC Disconnect (Knife) Switches
6. Section 34 21 41 DC Disconnect (Knife) Switch Enclosures

1.03 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 5 thru 8.

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 5 thru 7.

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.

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 General and Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

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.

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 General and Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

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 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

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 Authority.

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

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 General and 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 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.

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.

3. The work shall be performed in stages to facilitate the minimum interruption for Authority's Schedule Service. 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.

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 recommended spare parts list 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 CTA 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.

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 General and Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

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 90ºC 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

b. 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)(ºF/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/ºF	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

i. 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

i. 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^{o}F to +1850^{o}F	ASTM E119
(1850^{o}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 x 10^{+6} psi	ASTM D2105

5. Toxicity:

a. The following shall be the maximum values when tested in accordance to ASTM E-800:

E. 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

F. 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.

G. 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:

i. 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.

ii. 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:

i. 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.

ii. 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:

i. 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:

i. Data to be supplied by the Contractor for each type of size of wire and cable furnished shall include:

i) Number of conductors, materials, stranding
ii) Voltage rating of insulation
iii) Temperature rating of insulation
iv) Insulation material and thickness
v) Jacket material and thickness
vi) Overall diameter
vii) Weight, lbs/1000'
viii) 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.

3.09 FILLING OF OPENINGS

A. 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.

B. Close unused openings or spaces in floors, walls and ceilings. Plug or cap unused conduit and sleeves.

3.10 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.

END OF SECTION

SECTION 34 21 68
TRACTION POWER UNDERGROUND DUCTBANK AND MANHOLES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section covers the construction and placement of underground traction power duct banks and manholes as site infrastructure.

B. Furnish and Install

1. The following items and accessory materials are addressed:

a. Ducts in concrete-encased duct banks.

b. Manholes and manhole accessories.

c. In ground cable trough.

C. Related Sections

1. The following sections contain requirements that relate to this section

a. Section 03 30 00; "Cast-In-Place Concrete"

b. Section 31 20 00; "Earthwork"

c. Section 31 20 10; "Earthwork for Underground Utilities"

d. Section 34 21 65; "Basic Electrical Materials and Methods"

1.03 APPLICABLE STANDARDS, CODES AND REGULATIONS

A. The current editions of the referenced standards are a part of this section.

B. Manholes

1. AASHTO - Standard Specification for Highway Bridges.

2. AREMA – Manual for Railway Engineering.

3. ASTM A153 – Standard Specification for Zinc Coating of Iron and Steel Hardware.

4. ASTM A48 – Standard Specification for Gray Iron Castings

5. ASTM C478 – Standard Specification for Precast Reinforced Concrete Manhole Sections.

1.04 SUBMITTALS

A. The Contractor shall submit catalog data as required per Standard Specification, Section 01 33 00, Submittal Procedures.

PART 2 PRODUCTS

2.01 GENERAL

A. All materials shall be new and applicable as listed, labeled, or approved by the Underwriters' Laboratories, Inc. Defective equipment or equipment damaged in the course of installation or test shall be replaced or repaired in an approved manner.

2.02 UNDERGROUND CONDUIT DUCTS:

A. The Contractor shall furnish materials and construct underground conduit ducts. Ducts shall be cast-in-place monolith construction and shall be of reinforced construction as shown on the drawings. All underground ducts constructed outside the perimeter of the substation shall be pigmented red concrete. Pigment shall be #20 Earth Tone Red (Conduit Red) as manufactured by Dynamic Color Solution, Inc. or approved equal. Pigment shall be added at a rate of 25 pounds per cubic yard.

B. The Contractor shall cooperate with other contractors in installing work which may affect his work. He shall make proper arrangements to avoid interference with other trades, and shall cooperate with the Commonwealth Edison Co., SBC and Peoples Gas Co. in their installation of underground ducts to underground duct extension sleeves and/or openings provided under this Contract.

C. Concrete and metal reinforcement for ducts shall be as follows: Peripheral reinforcing shall be #4 deformed bars with 20 times the diameter overlap on 10 inch centers. Ties shall be #4 with minimum 12 inch overlaps 18 inch centers.

D. All conduit shall be non-metallic fiber reinforced epoxy conduit (RTRC). General requirements for RTRC conduit are specified under section 34 21 65 – "Basic Electrical Materials and Methods".

E. Conduits furnished and installed shall be complete with all couplings, adapters, bends and supports as required. Unless otherwise specified, all conduits entering manholes or ending inside substation spaces (walls or floors) shall be terminated using end bells. Where ducts by the Contractor will connect to existing ducts, the Contractor shall make the required conduit connections at the construction joint.

F. To maintain proper spacing between the conduits in the duct/banks the Contractor shall install conduit spacers. Spacers will be used for fiberglass reinforced epoxy conduits to achieve approximately a 2 inch separation between the conduits. The spacers mentioned above are specified to achieve required spacing for fiberglass reinforced epoxy conduit (RTRC). If other approved manufacturers conduits or spacers will be used, the Contractor shall make sure that proper spacing will be maintained and/or specified. Contractor is also required to purchase at least 3 extra spacers to provide for breakage during construction.

G. The conduit couplings shall be staggered so that no coupling is less than six inches from the coupling on an adjacent conduit row or tier so as to provide a duct line having maximum strength.

H. To prevent duct distortion during concrete installation, the conduits will be strapped together with nonmetallic straps of proper strength, at no more than 8 feet intervals. A sufficient number of hold-down bars, shall be installed to prevent conduit uplift during concrete installation.

I. The Contractor shall have fiber reinforced epoxy conduit manufacturer's representative advice and check on proper concrete enclosed duct bank installation procedures before the duct is covered with concrete. However, the fact that the manufacturer representative checked the installation and advised on procedures will not relieve the Contractor of his responsibility under this Specification.

J. During construction, partially completed duct shall be protected from the entrance of debris such as mud, sand and dirt, by means of suitable conduit plugs. As each section of a duct is completed, a testing mandrel not less than 36 inches long with a diameter 1/4 inch less than the size of the conduit, shall be drawn through each conduit, after which a brush with stiff bristles shall be drawn through until the conduit is clear of all particles of earth, sand or gravel, conduit plugs shall then be immediately installed.

K. Backfilling in areas away from the tracks shall be well compacted by means of hand or machine tampers. Backfill shall be placed in successive layers not more than 12 inches deep and each layer shall be thoroughly compacted with tampers before the next layer is placed. Backfill shall be entirely free of frozen earth, vegetation, lumber, brickbats, rocks or concrete rubble.

L. To avoid water seepage to the substation the Contractor shall install sealing bushings 0Z GEDNEY, Mac Products or approved equal inside the substations. Blank sealing bushings shall be installed on all spare conduits.

2.03 PRE-CAST MANHOLES

A. Manufacturer shall have documented experience in the manufacture of manholes for a minimum of five years.

B. Sub base material shall be 3 to 4 inches of sand over native subgrade compacted to 95% standard Proctor density.

C. Precast concrete: Air-entrained, 5,000-psi compressive strength at 28 days.

D. Roof design live load: AASHTO H20 highway loading with 30% increase for impact.

E. Wall design live load: AREMA Cooper E80 train loading.

F. Inside Dimensions: As indicated on drawings.

G. Manhole Shape: As indicated on drawings.

H. Ductbank openings: As indicated on drawings.

I. Provide grooved opening in top section for frame and cover.

J. Provide end bell type terminators for each ductbank entry.

K. Provide cable support hardware and all supports for all cable, cable splices and cable terminations as required for support of cables inside manhole.

L. Provide 24 inches inside diameter by 36 inches deep (minimum dimensions) precast sump. Slope floor toward sump.

M. Ram-Nek, Kent Seal or approved equal sealants shall be used to seal the joints in the manhole.

2.04 CAST-IN-PLACE MANHOLES

A. Excavate, install base material, and compact base material. Compact subgrade to 95% standard Proctor density or as required by manufacturer.

B. Concrete: Air-entrained, 4,000-psi compressive strength at 28 days.

C. Install, seal, and waterproof precast sections in accordance with manufacturer's instructions.

D. Use precast ring sections to bring manhole entrance to proper elevation.

E. Install manhole plumb.

F. Provide cable support hardware and all supports for all cable, cable splices and cable terminations as required for support of cables inside manhole.

G. Provide 24 inches inside diameter by 36 inches deep (minimum dimensions) sump. Slope floor toward sump.

H. Set the top of each manhole cover to finished elevation.

I. Install a one-foot wide concrete (3,000 psi, ¾-inch aggregate) collar around the manhole, unless noted otherwise on drawings.

J. As a minimum the height of the concrete collar should go from the top of the manhole cover to eight inches below grade.

K. The top of the concrete collar shall slope down away from the cover so that no water will accumulate around the cover.

2.05 MANHOLE ACCESSORIES

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, 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

C. Pulling Irons: 7/8-inch diameter steel bar forming a triangle of 9 inches per side when set. Galvanize to ANSI/ASTM A153 for irregular shaped articles. Locate opposite of each duct entry.

D. Cable will be tied to the cable racks with cross-wise nylon ties.

E. Cable support racks shall be "Underground Devices", Catalog No. RA20 or equal.

F. Cable rack channels shall be "Underground Devices", Catalog No. CR36 or equal.

G. Manhole Ladder: One ladder for each manhole entrance shall be fire retardant yellow fiberglass reinforced plastic (FRP), extruded structural shapes. Ladders shall have 2 inch x 2 inch square tube ¼ thick side rails 18 inches apart, and 1 3/8 inch round rungs with grit top non-skid surface set into and joined to side rails and spaced approximately 14 inches apart. The length of the ladder shall extend from the bottom of the manhole to within 3 inch of the cover, and shall be anchored top to bottom. Anchors and hardware shall be stainless steel, and shall be designed so that ladders can be readily removed.

H. Grade Rings: Pre-cast concrete (5000 psi. compressive strength at 28 days) with inside diameter equivalent to manhole opening specified in Part 2.5A. The ring shall have circumferential rebar #3 minimum with a trowel finish to provide a true plane within 1/8 inch, as determined with a 5-ft straight edge.

I. Sump Covers: ASTM A48; Class 30B gray cast iron.

J. Manhole Frames and Covers: Per STP-900 or STP-901 as applicable.

2.06 POLYMER CONCRETE CABLE TROUGH

A. Polymer concrete cable trough and covers shall be composed of dielectric fiberglass reinforced high density polymer concrete material. Polymer concrete material shall consist of calcareous and siliceous stone, glass fibers and thermoset polyester resin.

B. Cable trough shall be designed to accommodate a 1° bend over two (2) joined sections and up to a 3° bend over five (5) sections which shall be sufficient to permit cable trough to parallel track curvature without modification. For tighter bend radius, design and furnish elbow sections which shall be compatible with all other trough materials supplied.

C. Cable trough shall allow for drilling with a hole saw for cable and conduit.

D. All mounting and fastening hardware shall be either hot-dip galvanized steel, bronze or nonmagnetic stainless steel, type 304.

E. Cable trough covers shall incorporate a non-skid surface design to mitigate slipping hazard.

F. Polymer concrete cable trough and cover assemblies shall be capable of withstanding AASTHO HS-20-44 wheel loading. Polymer concrete cable trough and cover assemblies shall be capable of withstanding a vertical design load of 20,800 pounds (16,000 lb. plus 30% impact factor) over a 10”x 20”x 1” steel plate backed with a 10”x 20”x 1/2” rubber pad.

G. Polymer concrete cable trough shall be Armorcast cable trough or approved equal.

PART 3 EXECUTION

3.01 CONDUITS

A. Where underground crossings are known, field verify horizontal and vertical locations prior to excavation and placement of conduit. Notify the Engineer of any deviations to the drawings. Any profile changes and existing utility line crossings are to be as built on drawings showing: type of line, size, and depth below the surface.

B. Install at 36” minimum depth of burial to top of electrical ductbank (top of concrete to finished grade), unless otherwise noted in drawing. If site conditions do not permit this depth of burial, contact the Engineer for instructions.

C. The ducts shall have a continuous slope downward toward manholes and away from the substation buildings with a pitch of not less than 2 inches in 100 feet unless noted otherwise. Changes in direction of runs exceeding a total of 10 degrees, either vertical or horizontal, shall be accomplished by long sweep bends having a minimum radius of curvature of 25 feet, except that manufactured bends may be used at ends of short runs of 100 feet or less, and then only at or close to the end of the run. The long sweep bends may be made up of one or more curved or straight sections or combinations thereof. Manufactured bends shall have a minimum radius of 36 inches for all ducts. No more than 270 degrees total bend shall be allowed in any one run.

D. Ducts shall be laid in trenches having solid, level and undisturbed bottoms. The Contractor shall perform all excavation and backfilling, including breaking of and/or replacement of concrete necessary for the installation of his work. If excavation is made to a depth greater than elevation required, the Contractor shall backfill with properly tamped CA-6 or CA-7 aggregate at his own expense to correct elevation. Method of conduit installation shall be in strict accordance with manufacturer's recommendations

E. Spacers shall be used where more than one duct is installed and shall be the standard product of the duct manufacturer for the type and size duct. They shall be located at not more than five-foot intervals, secured to the ducts with #16 gage iron wire. The spacers shall be securely anchored every ten (10) feet to the bottom of the trench to prevent ducts from floating during concrete pouring. Unless otherwise noted on drawings, provide a minimum of 2 inches clear spacing between conduits, horizontally and vertically and minimum of 3 inches clear concrete cover.

F. Preparation and placing of concrete shall be in accordance with provisions of Section 03 30 00, “Cast-In-Place Concrete.” Concrete mix design shall be a minimum of 3000 psi with maximum 3/4” aggregate and maximum 6” slump. Care shall be taken in the placement to prevent voids around the ducts. The top of the concrete encasement shall be a smooth finish accomplished by mechanical vibrator or spading the surface.

G. Terminate conduits in an end bell at manhole and building foundation penetrations. Stub-ups of rigid or IMC duct in equipment pads shall have insulated grounding bushings.

H. Conduit and duct runs shall be short, straight runs between points of the system.

I. Duct runs shall be graded to drain toward manholes. The slope shall not be less than 2 inches for every 100 ft. of length, unless otherwise shown on contract drawings.

J. Conduits and duct runs shall be installed on compacted soil when entering a manhole, building foundation, crossing a road, railroad track, or bridge abutment to prevent shear stress on the conduit.

K. All paving and concrete cuts shall be made with a concrete saw. All surfaces and structures to be replaced shall match existing condition.

L. Conduit penetrations into buildings, or through aboveground foundations, shall be sealed with duct seal or conduit sealer to prevent gas or water entry.

M. Trenching and backfilling shall be in accordance with Sections 31 20 00, “Earthwork” and 31 20 10, “Earthwork for Underground Utilities”.

N. Empty ducts running between manholes shall have a 1/4” polypropylene pull rope provided in each duct, with 3 feet of slack at each end, and with the ends secured to a suitable structure (not a conductor) inside each manhole.

O. Empty ducts not running between two manholes (i.e. between switchgear and a manhole, or switchgear and a transformer, etc.) shall be labeled at both ends with a Panduit Marker Plate (Model # MP350-C). The label shall be marked with a Sharpie Permanent Ink Pen and secured to the pull rope on the inside of the duct so as to indicate destination of the duct.

P. When multiple channel inner ducts (FO-DUCT) are pulled through conduit, secure every 10-ft section so as to prevent rolling of channels within conduit. Leave one-foot ends protruding from face of manhole.

Q. Conduit and duct banks shall maintain 1-foot vertical and 1 foot horizontal separation from other utility lines where possible.

R. Identify the ductbank location with metallic safety tape or vinyl tape with magnetic tracer marked "CAUTION! BURIED HIGH VOLTAGE ELECTRICAL LINE". Tape shall be located 12 inches above the ductbank.

S. Swab the duct at completion of construction. A mandrel approximately 1/4" smaller than the conduit shall be pulled through each conduit. A circular plastic wire brush with the same diameter as the conduit shall be pulled through the conduit. After cleaning, install caps as herein specified, to protect against the entry of dirt or moisture.

3.02 PRE- CAST MANHOLES

A. Excavate, install base material, and compact base material. Compact subgrade to 95% standard Proctor density or as required by manufacturer.

B. Install, seal, and waterproof precast sections in accordance with manufacturer's instructions.

C. Use precast grade ring sections to bring manhole entrance to proper elevation.

D. Install manholes plumb.

E. Set the top of each manhole to finished elevation.

F. Install a one-foot wide concrete (3,000 psi, 3/4-inch aggregate) collar around the manhole, unless noted otherwise on drawings.

G. As a minimum the height of the concrete collar should go from the top of the manhole cover to eight inches below grade.

H. The top of the concrete collar shall slope down away from the cover so that no water will accumulate around the cover.

I. Backfill around manhole using native material.

3.03 TRENCH BACKFILLING

A. Backfill using fine material up to 24 inches above the top of the ductbank placed in 6-inch lifts and thoroughly tamped.

B. Consolidate the ductbank fill material under roads or similar traffic areas in such a manner as to provide an unyielding foundation for the paving. Remove all excess materials.

C. Compact backfill by tamping or other method as approved by the Engineer. Maintain compaction at a minimum of 95 percent standard Proctor density.

D. Contractor shall assume full responsibility for any deficiency in quantity of material or filling of depressions caused by settlement of backfill material. Damage to other trade's work caused by settling shall be corrected at the Contractor's expense. Contractor shall assume full responsibility for damages to any underground utility lines or other structure.

E. Dispose of all excess material from the construction site as directed by the Owner. Contractor should remove excess spoils and other material from the site.

3.04 RECORD DRAWINGS

A. All duct bank locations shall be located with respect to site horizontal controls. All ductbanks shall be located at ends and change of directions. Record accurately all ductbank bends (radius and center point) on the construction As-Build drawings.

B. Record the installed length of each conduit in the ductbank to the nearest foot and transmit to the Owner's representative.

END OF SECTION

SECTION 34 21 70
SUPERVISORY CONTROL EQUIPMENT

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and General provisions of contract, including General and Special Conditions and Division 01 Specification sections, apply to this section.

1.02 1.02 SUMMARY

A. This part of the specification covers the detail requirements for supervisory remote terminal units (RTU’s) to be furnished and delivered for control, supervision, and data capture of new traction power substation equipment at each substation.

B. In addition, all hardware and software shall be furnished and added to the existing master station at the CTA's Communication Center to accommodate RTU's specified within this specification.

C. Supervisory remote (RTU's) furnished under this contract shall be compatible in all respects including adaptation and utilization of protocol with the master station apparatus manufactured by QEI which is presently in service at the CTA. It is expected and required that the bidder and/or successful supplier shall liaison with the Engineer to obtain the required data.

PART 2 PRODUCTS

2.01 DESCRIPTION

A. Furnish the following:

1. It is anticipated the RTU equipment supplied under this contract will be compatible with the existing master station and require no additional equipment at the Control Center master station. If however, a non-compatible RTU is chosen, all necessary expansion hardware and software at the CTA Control Center SCADA master station shall be provided.

2. One (1) SCADA RTU internal components (motherboards, power supplies, etc.) only to be installed in the existing cabinet, at Broadway, Substation. Internal wiring and terminal blocks can also be reused.

3. Successful factory acceptance tests of completed system conducted at manufacturer’s plant and certified (notarized) test data to the Authority.

4. Support parts needed to maintain state System.

5. One (1) year warranty, starting on the day of Final System Acceptance, on all WORK provided under the Contract.

6. Delivery of all material and documentation (including software source code).

7. 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.

8. 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.

9. One (1) SCADA System test set.

10. 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 equipment 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.

e. Non-U.S. suppliers shall adhere to the U.S. standards listed.

f. The SCADA Master Station, in addition to the existing RTU communication, shall communicate with these new remote terminal units (RTUs) by three possible communication media:

i. Redundant Bell 202 modems over redundant 2-wire CTA-owned unconditioned metallic conductor lines and/or local telephone line supplier telephone lines.
ii. Redundant RS232 serial data ports over communication multiplexing equipment provided by the CTA. These ports shall be capable of supporting both terminal protocols (such as L&G8979) and network WAN protocols such as PPP. One port shall be supplied with the required networking stacks to support CDPD communications.
iii. Ethernet IEEE 802.3 over a communication link provided by the CTA. The Ethernet interfaces available shall include 10baseT, 100baseTX, and 100baseFX.

g. The 202 modem data transmission communication line wires shall be one or two pairs of CTA-owned unconditioned metallic conductors or/and the local telephone line supplier voice grade dedicated PL2001 circuit lines to each or groups of RTUs. One channel pair as main and the other channel pair as alternate where two pairs of communication line are available. The data transmission shall be such as not to interfere with other services in a combined telephone and supervisory control cable. Current flow and voltages shall be within the limit values specified by the local telephone line supplier. The supervisory control system shall be designed for data transmission communication over the Authority existing cable communication system.

C. Security/Reliability

1. To minimize the chance of false operation or failure of the equipment, the equipment proposed shall have as a minimum the following features:

   a. All control operations shall employ a select-check-before-operate technique. Initiation of a select sequence shall start an adjustable timer. If the operator does not activate a command message within the allotted time, the system shall cancel the selected point.

   b. Receipt of a selection code by the remote station shall cause the equipment to verify the normal operation of the control logic. The verification process shall prevent improper control operations due to failure of the decoding or output logic. As a final check, the remote station shall prevent the operation of more than one interposing relay during the command operation.

   c. Message security shall be insured by using a high security code for all information transfers between stations. The code shall be equivalent in security and efficiency to either a BCH 31/26 or a BCH 31/25 code or crosshatch parity error detection encoding.

   d. All status inputs, transducer inputs and control outputs shall be designed to meet or exceed the requirements of the IEEE surge withstand test for supervisory control equipment, without sustaining any damage.

   e. A feature shall be included in the system, such that false commands cannot be generated during a power off/restart cycle. This feature shall be included in the master and remote stations.

2. All control commands from master station to remote station RTUs shall be treated with priority. These control commands shall be used to control circuit breakers, automatic-reclosing load-measuring Direct Current (dc) feeder breakers, starters and other apparatus units with two (2) and three (3) state controls.

3. The supervisory control functions involved in the control of apparatuses shall have the following capabilities:

   a. All dispatcher-requested control selections shall be checked for proper conditions for control of the device (no other control action in progress at this RTU, this point not selected for control at another console, control of this point is allowed from this console, no control inhibit tag effective for this point, all specified permissives satisfied).

b. The system shall acknowledge this feasibility and show the dispatcher that his selection has been verified (select-before-operate).

c. The dispatcher will either cancel his selection or execute the control command within a predetermined time interval (configurable). In the latter case, the system shall perform the checkback-before-operate sequence from master to RTU, from RTU to master, from master to RTU and after completion, acknowledge the execution of his command.

d. After detection of change of state in the RTU, the status shall be analyzed to ascertain that the proper control action took place.

e. The system shall update the SCADA system database. Display to the operator of the change of state from the RTU shall not exceed three (3) seconds. Commands issued by the Master Station to the RTU shall be executed within one-half (0.5) of a second.

f. If communication errors occur during the check-before-operate sequence, the System shall retry the operation up to three times in succession (configurable number). If it is impossible to obtain proper communication or if the RTU does not respond with the proper message, the dispatcher shall be alarmed with an appropriate message different from the time-out message.

4. The system shall be designed to ensure that no change of status is lost due to communication errors or other causes.

5. During operation, the master station shall periodically poll for all data at each remote. The master station software shall calculate and display all the communication error rates for each remote station.

6. The master station shall report the status of all RTU communication statistics on a real-time basis.

7. The equipment shall have been designed with ease of maintenance as one of its prime requisites.

D. Master Station Computer Hardware Expansion

1. The SCADA Master Station computer hardware shall be expanded to accommodate all RTUs supplied under this specification.

2. Expansion of the CTA's SCADA Master Station hardware shall follow the existing system architecture. Any deviations from this or modifications to it require the written consent of the Authority's Project Manager.

3. Master Station hardware shall support single or multiple RTU on one (1) communication port.

4. The included hardware shall include, but not be limited to the following list in quantities as required:

a. Ethernet Communication Interface Ports

b. Redundant RS232 Serial Data Communication Ports

c. Redundant 202 Communication Modems

d. Ground Fault Detection Hardware

e. Power Supplies

f. Line Protection Hardware

g. Line Switching Hardware

h. All interconnecting wiring/cabling required

i. Enclosures as required

j. Cabinet enclosure for system hardware and accessory

5. Communication Line Termination Facilities

a. Communication line termination cabinet facilities for connection to the master station cabinet for each RTU shall be provided.

b. These facilities shall include, but not be limited to, four (4) communication line switches to allow individual telephone wires to be selected and grouped as main or alternate pairs. Line protection devices for each incoming line and monitoring capabilities to detect grounded conditions on any line associated with a RTU termination port. Three communication and test Bantam plug jacks shall be provided for isolate and monitor communication between RTU to Master, Master to RTU, line monitoring, for each of the communication lines.

6. RTU Communication

a. The Master Station expansion equipment shall consist of four (4) Communication Interface independent communication circuits. The CIU architecture shall allow implementation of communication for each of the 16 communication channels over three possible communication media:

i. Redundant Bell 202 modems over redundant 2-wire CTA-owned unconditioned metallic conductor lines and/or local telephone line supplier telephone lines.
ii. Redundant RS232 serial data ports over communication multiplexing equipment provided by the CTA.
iii. Ethernet IEEE 802.3 over a communication link provided by the CTA. The Ethernet interfaces available shall include 10baseT, 100baseTX, and 100baseFX.

b. Each RTU shall be equipped and configurable for communication over three communication media: redundant 2-wire lines, redundant RS232 serial data ports, or IEEE 802.3 Ethernet (10baseT, 100baseTX, or 100baseFX).

c. All 202-modem data transmission shall be FSK at 1200 baud. The modems shall have easily accessible strap adjustments for transmit output level and receiver sensitivity. The modems shall comply with CCITT, Bell 202 specification.

d. The Contractor shall verify with the CTA on the exact SCADA master station equipment requirement to support the number of SCADA RTU(s) specifically for this project.

7. Ground Fault Deduction System

a. The supervisory control system shall include ground fault detection (GFD) system at the master station for detecting grounds 202 modem communication line wires. The GFD units shall provide local LED indications as well as status inputs to a local RTU to provide Visual and audible alarms on the Master Station operator interface to alert the Power Controller to the occurrence.

b. The GFD units shall be capable of sensing a resistance to ground with an adjustable range between 5,000 Ohms and 50,000 Ohms anywhere on the supervisory data transmission line wires. Outputs of GFD circuits shall be dry contacts and LED indicator configuration as “energized in normal”.

c. The GFD system shall be energized from an independent dc power supply rectified and filtered from an isolated 120V ac, 60 Hz source.

d. A "ground" at only one point on the data transmission line wires shall not cause a LINE SUPERVISION alarm or impair operation of the system (LINE SUPERVISION is defined as loss of communication between the Master Station and the RTU).

e. In the event of a direct short to ground of any part of the supervisory equipment monitored by the ground detectors, the ground detector current shall not exceed 1.0 milliampere. At no time shall the GFD cause the communication line control wire voltage or current to exceed limitations imposed by the local telephone line supplier.

8. Data Cartridges

a. Contractor shall supply thirty-two (32) blank 4-Gigabyte 4mm DAT tapes for the servers to be used as required for SCADA and system database and system application update and software maintenance purposes.

9. Other Master Station Hardware

a. Appropriate hardware and enclosures shall be included for the expansion of the master station to support the additional specified RTUs.

10. Environment

a. All SCADA master station hardware shall operate in an indoor office environment with no special air conditioning requirements.

i. Operating Temperature: +10C to +40
ii. Humidity: 10% to 90%
iii. Voltage: 88 to 132V ac
iv. Frequency: 47 to 63 Hz

E. Master station computer Software

1. General

a. Contractor shall provide RTU system communication and configuration so CTA can configure and test Master SCADA to RTUs to Master SCADA communication.

b. Operating display and database point configuration will be prepared by CTA.

F. Remote Terminal Unit (RTU)

1. General

a. The remote terminal units shall collect device status data and provide control for controllable devices. The flow of information to and from the remote shall be initiated by and originated from the CTA Master Station.

b. The RTU shall be subjected to the environment relative to its respective location and shall include of the auxiliary end equipment necessary for the control and/or supervision of said auxiliary location.

c. The remote station RTU enclosures shall contain, but not be limited to, solid state circuit boards, interposing relay panels, semiconductor rectifier power supplies (copper oxide type not acceptable), ground detectors, communication equipment, terminal blocks, fuse block and switches as required.

d. The RTU shall be microprocessor controlled such that changes in their operation may be made by merely changing memory elements. System input/output boards shall be cable connected to logic boards and arranged such that future expansion of the RTU may be made with minimum effort and not require special tools or knowledge.

e. The SCADA Master Station shall communicate with the remote terminal unit (RTU) by means of three possible communication media:

i. Redundant Bell 202 modems over redundant 2-wire CTA-owned unconditioned metallic conductor lines and/or local telephone line supplier telephone lines, using QUICS 3000 or L&G 8900 Protocol.
ii. Redundant RS232 serial data ports over communication multiplexing equipment provided by the CTA. These ports shall be also capable of supporting both terminal protocols such as L&G8979 or QUICS 4000 and network WAN protocols such as PPP. One port shall be supplied with the required networking stacks to support CDPD communications.
iii. Ethernet IEEE 802.3 over a communication link provided by the CTA, using UCA v3.0 protocol. This protocol shall be in accordance with the standards set by the EPRI Substation Utility Initiative or IEC 61850 and shall employ the generic set of objects as defined by GOMSFE. The RTU'S supplied shall be certified to be compatible and able to read GOOSE messages. The contractor shall submit certification of compliance from the EPRI Substation Utility Initiative or some other recognized testing agency The RTU'S shall employ both TCP/IP and OSI seven-layer networking stacks for communications. The TCP/IP stack shall be used for Inter-Station and Master station communications and the OSI stack for IED Intra-Station communications. The Ethernet interfaces available shall include 10baseT, 100baseTX, and 100baseFX. Two (2) Ethernet interfaces are required to support communication to two (2) independent hosts

f. Each RTU shall be equipped and configurable for communication over three communication media: redundant 2-wire lines, redundant RS232 serial data ports, or IEEE 802.3 Ethernet (10baseT, 100baseTX, or 100baseFX). This shall include installation of the required protocols.

g. All 202-modem data transmission shall be FSK at 1200 baud. These modems shall have easily accessible strap adjustments for transmit output level, receiver sensitivity, and selectable pre-emphasis compensation for high frequency attenuation. The modems shall comply with CCITT, Bell 202 specification.

h. Current flow and voltages over the local telephone line supplier’s lines shall be within the limit values specified by the local telephone line supplier. The supervisory control system shall be designed for data transmission communication over the Authority’s existing cable communication system. Modems shall be capable of accommodating variations (without degradation in communications) in line impedance, delay distortion, etc., which may be expected on these types of circuits. The successful bidder shall submit a complete set of modem specifications for approval by the Authority's Project Manager before production of the equipment.

i. Where dedicated SCADA communication lines are not available for a RTU to communicate with the Master Station, the RTU shall communicate with the Master Station via another RTU that has dedicated SCADA communication line(s) to the Master Station.

j. For each telephone line wire, suitable line protective equipment of the self-restoring type shall be furnished in the RTUs to protect against high voltage surges. Each pair of line wires shall be protected by a single, common-envelope type protector.

k. RTU shall have protection in the event of accidental contact with 600V dc.

l. The input to the remote stations shall be status points and analog measurement points. RTU output shall be control points.

m. Equipment shall be furnished as required to permit the control and supervision functions required as stated in section 3.5.10.

n. RTUs shall be equipped to affect automatic transfer to emergency power in the event of failure of normal power at the RTU. Upon restoration of normal service the RTU shall automatically return to the normal power supply.

o. The RTU shall support programmable calculation and control algorithms. These shall be written on a portable notebook/laptop computer using a script editor. These shall be compiled and loaded into non-volatile memory in the RTU. The RTU shall have the capability to upload the script to the Master Station. In the event of a failure of the RTU or corruption of the script file, the Master Station shall download the file into the RTU. The file format shall be compatible with the current storage system at the master station.

p. As a minimum, the calculation and control routines shall support the following mathematical and logical functions: Add, subtract, multiply, divide, assign, log, exponential, sine, cosine, tan arcsine, arccosine, arctan, equal to, not equal to, greater than, greater than or equal to, less than, less than or equal to, square root, absolute value, reciprocal, AND, OR, NOT, XOR.

q. The available database for the above shall include: Local status values, local analog values, local accumulator values, set point values from Master Station, Control requested from the Master Station, date and time variables, communications failure.

r. Function shall include: Set status value, set analog value, set accumulator value, set point control value, execute local controls, start local timer.

s. The RTU shall have built-in circuit to detect and isolate a grounded SCADA communication line from the RTU, so a "grounded" at only one point on the data transmission line wires shall not cause a LINE SUPERVISION alarm or impair operation of the system (LINE SUPERVISION is defined as loss of communication between the Master Station and the RTU).

t. The RTU'S central processing unit shall be based on a 32 bit microprocessor and shall support up to nine (9) communication ports for connection of: the dual master station communication modems, test set and RTU configuration, communicate with intelligent electronic devices such as “smart breakers”, PLCs, metering devices and wayside train signal equipment. Each port shall be capable of supporting independent protocols with multiple devices connected at baud rates up to 19.2 kbps. Port configuration, data point mapping, shall be easily changed using the RTU/SCADA system test set.

u. The RTU'S will have the capability of creating a terminal session with other devices in the Station using RS-232 ports. This shall allow the use of third party software at the master station to communicate with Station hardware to allow extraction of auxiliary data or reprogramming the device from the Master Station.

v. The RTU shall have built-in output connector for radio communication: RS-232, pull-up jumpers for CTS, DCD, with PTT control, 6-bit open collector current sinking, 500mA per bit, 900mW combined, external synchronous transmit/receive clocks signal.

w. RTU modules and components shall have isolation and protection against system failure (such as high voltage surges - greater than 150V ac or dc) so failure of a single point in the RTU will not impair other components or module in the RTU or the operation of the RTU.

x. The RTU shall have a dedicated port to allow the time synchronization with an external time source, and the RTU's internal application shall be able to synchronize the time through the TCP/IP communication from the master station system.

2. Status Points

a. Input points for status monitoring shall be isolated dry contacts. These shall be monitored by the remote station with the following provisions:

i. All status points associated with an RTU shall be interrogated by the RTU at least once every 10 milliseconds.

ii. The RTU shall be equipped such that if a device change of state occurs, but disappears before that remote is polled by the master station, the change is not lost. Storage for up to seven (7) changes of state per status point must be available.
iii. All RTU input shall be protected against voltage surges and shall meet the IEEE surge withstand test.
iv. Separated industrial barrier type interposing terminal blocks shall be provided for all interface connections between the Authority's equipment and the SCADA RTU inputs. These terminal blocks shall accommodate up to #14 AWG wire, and shall be TRW Cinch Jones Series 141 dual barrier style with 16 terminals per block with marker strip or approved equal.
v. Local LED indications shall be provided to display the state of all status points.
vi. Circulating current to dry contacts shall be supplied by the RTU at a 48V dc level. Non-shielded wires will be used and the input point shall not be affected by electromagnetic and electrostatic interferences. The input points shall be capable of operating from contact devices up to 2500 feet from the RTU over #18 AWG non-shielded wires.
vii. Point address assignment per equipped module shall be dip-switch and/or jumper selectable.
viii. Status input module shall be equipped with LED with configuration as “energized in normal” to indicate the working status of the module. LED shall be off when a failure occurred.
ix. Failure of a single status input point or module should not impair other points in the module or other modules or the operation of the RTU.

3. Analog Points

a. Input points for measurement will be analog signals. The input panels shall be capable of handling the following types of signals:

i. 0 - 1 mA dc

b. These inputs shall be monitored with the following provisions:

i. The accuracy of the conversion equipment shall be more than 99.9%.
ii. To minimize transverse mode noise problems, the input multiplexer shall switch both leads of the signal to preserve the balance of the analog signal.
iii. To minimize common mode noise problems, the analog inputs shall be electrically or optically isolated from the digital logic of the remote station.
iv. Separated industrial barrier type interposing terminal blocks shall be provided for all interface connections between the Authority's equipment and the SCADA RTU inputs. These terminal blocks shall accommodate up to #14 AWG wire, and shall be TRW Cinch Jones Series 141 dual barrier style with 16 terminals per block with marker strip or approved equal.

c. Point address assignment per equipped module shall be dip-switch and/or jumper selectable.

d. Analog input module shall be equipped with LED with configuration as "energized in normal" to indicate the working status of the module. LED shall be "off" when a failure occurred.

e. Failure of a single analog input point or module shall not impair other points in the module or other modules or the operation of the RTU.

f. A Direct Current Trace Recorder (DCTR) shall be provided to capture oscillographic data and real time data on the source of the analog input. The DCTR shall consist of a microprocessor based, distribution automation device designed to provide rapid collection of data samples for a 0-2 ma analog input signals when triggered by a corresponding status input signal or by remote command. The DCTR shall support retrieval of current operational data, provide long term storage of the collected samples, provide transmission of the stored data to remote systems, and shall be capable of simultaneously sending continuous streaming data of the real-time sample values to a network port. The DCTR data capture mode shall capture up to 1000 samples per second and store 4000 samples in a capture file with time stamped that synchronized to the time source on the RTU. The DCTR streaming data mode shall send up to 50 samples per second to a TCP/IP socket for remote monitoring. The DCTR shall be capable of communication with external devices via a serial RS232 port or Ethernet connections including multimode/single mode 100BaseFX, 100BaseTX, and 10baseT. The DCTR shall have configurable variable to hold the current value, maximum value, minimum value, and average values for each input. The number of DCTR inputs as required per each RTU shall be as defined in Appendix "A".

4. Control Points

a. Output points for control shall be isolated contacts from interposing relays provided by the Contractor. The following provisions shall be made in the RTU for all control points:

i. All control operations shall be on a select-check-before-operate basis.
ii. All outputs shall be protected such to meet the IEEE surge withstand test.
iii. Separated industrial barrier type interposing terminal blocks shall be provided for all interface connections between the Authority's equipment and the SCADA RTU inputs. These terminal blocks shall accommodate up to #14 AWG wire, and shall be TRW Cinch Jones Series 141 dual barrier style with 16 terminals per block with marker strip or approved equal.
iv. As a minimum, two "form C" contacts from each and every interposing control relay shall be wired to an interposing terminal block as specified in section 2.F.9 and section 2.F.13.
v. Momentary output contacts shall be closed for an adjustable time interval. Timer shall be adjustable from 0.5 to 15 seconds.
vi. The contact rating and type of control relays shall be as specified in section 2.F.9.
vii. Point address assignment per equipped module shall be dip-switch and/or jumper selectable.
viii. Failure of a single control point or module shall not impair other points in the module or other modules or the operation of the RTU.

5. Security and Reliability

a. Security and reliability shall be integral to the RTU design concept such that proper consideration is given to communications, hardware, software, assembly and construction of the RTU itself.

6. Communication Path Security

a. The RTU's encoding/decoding of information shall guard against false commands being executed and prevent false data from being transmitted to the master station. As a minimum the following security features are required:

i. BCH error detection coding or equivalent crosshatch parity error detection encoding.
ii. Re-encode and retransmit (to the master station) part or all of the information request and control request messages according to existing master handshake methods including the method employed for redundancy of communications lines.
iii. Select-check-operate control technique.

7. Internal Operation and Construction Security

a. As a minimum, the following features are required:

i. High stability clocks for internal timing. The time base of all RTUs shall be periodically synchronized by the Master Station to insure Sequence of Event accuracy and a time base for calculate and control programs.
ii. Coded trip/close, start/stop, low speed/high speed/stop, forward/reverse/stop, and all other control commands.
iii. Selection interlocks to prohibit operation of more than one control point selection at a time in an RTU. RTU logic shall be such that only a previously selected point can be controlled
iv. Automatic selection reset at the RTU to reset (clear) a control selection for a point if the next message from the SCADA master is not the "operate" message for that point
v. False control operation or false or continuous transmission to the master station shall not be caused by any or all of the following:

i) Power up of the RTU
ii) Switching from the primary power source to the back-up source
iii) Communication circuit failure
iv) Any component failure in the RTU
v) A logic card left out of the RTU

vi. The RTU design shall be modular for ease of maintenance and expansion. Failure of one card containing a group of input or output points shall not disable the entire RTU. The RTU reliability shall be high, with a mean time between failures (MTBF) of least 60,000 hours.

i) The manufacturer shall provide details of all data security features for the review/approval of the Authority's Project Manager prior to the start of the manufacturing process.
ii) Integrated circuits using circuit types other than CMOS logic shall require the approval of the Authority's Project Manager prior to the start of the manufacturing process.

iii) High reliability off-the-shelf components and modules shall be used throughout the RTU.

8. RTU Hardware

a. All RTU shall have a control panel. The panel shall be easily accessible once the door of the RTU is opened. On this panel shall be mounted the following devices:

i. Four (4) line transfer switches, each a single pole double throw with center "OFF" position, labeled L1, L2, L3 and L4. Switches (L1, L2, L3, and L4) permit one communication line to be used as active and the other as standby or to permit isolation of any or all of the lines. Each communication line shall have a separate input and output isolation device such that a problem on one line shall not affect the other.

ii. Three communication and test Bantam plug jacks for isolate and monitor communication between RTU to Master, Master to RTU, line monitoring, for each of the communication lines.

iii. A ground fault detection (GFD) system for detecting grounds on the dc power supplies and on 202 modem transmission line wires. The GFD units shall provide local LED indications as well as status inputs to a local RTU to provide Visual and audible alarms on the Master Station operator interface to alert the Power Controller to the occurrence.

i) The GFD units shall be capable of sensing a resistance to ground with an adjustable range between 5,000 Ohms and 50,000 Ohms anywhere on the 202 modem transmission line wires or on the RTU positive or negative DC power lines. Outputs of GFD circuits shall be dry contacts and LED indicator configuration as energized in normal.

ii) The GFD system shall be energized from an independent dc power supply rectified and filtered from an isolated 120V ac, 60 Hz source. The negative supply potential of the ground detectors shall be connected to ground, or structure as appropriate.

iii) A "ground" at only one point on the data transmission line wires shall not cause a LINE SUPERVISION alarm or impair operation of the system (LINE SUPERVISION is defined as loss of communication between the Master Station and the RTU).

iv) In the event of a direct short to ground of any part of the supervisory equipment monitored by the ground detectors, the ground detector current shall not exceed 1.0 milliampere. At no time shall the GFD cause the communication line control wire voltage or current to exceed limitations imposed by the local telephone line supplier.

iv. The "ON-OFF" POWER switches. This shall be two (2) positions, single throw switch which shall disconnect the RTU from the primary and emergency power supplies.

v. A Local/Remote switch with LED indication for method of disconnect power supply to energize all RTU Control Points shall be provided. Contact for indication on position of this switch shall be available as status input for RTU with normally closed contact being in remote position. With switch in local position, any RTU control commands shall return 'hardware error' (control relay not energized - control function disabled). This " 243" switch shall be a two (2) position multiple rotary type permitting disconnection of one side of all interposing relay contacts from substation equipment. The contacts of this switch shall be rated for continuous current-carrying capacity of 10 amperes each with an interrupting capacity of 2 amperes at 125V dc. The “243” switch shall be an Electro Switch Corp. “series 21” switch or approved equal. Switch contact quantity and configuration shall be as required for each RTU. Disconnection of the interposing relay contacts should not prevent the interposing relay from operating. Contact for indication on position of this switch shall be available as status input for RTU with normally closed contact being in remote position.

vi. An LED for indication if RTU is being powered by the backup power supply (in the event of loss of ac power supply) and contact output for RTU status input indication when such an event had occurred (normal when energized - ac power available).

9. 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. The interposing relay and device panels shall be wired in such a manner that additional intra-panel wiring required for future expansion shall be plug-in cables, with connectors keyed to prevent improper connection. All interposing relays furnished with the RTU shall be installed complete with all necessary wiring. All interposing relays shall be mounted inside the 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.

10. 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".

11. 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

12. Power Supply, DC/DC Converter, UPS System

a. Power for RTU operation shall be fully isolated from all input voltages, including ground reference. (Floating ground).

b. RTU shall have all necessary power supplies/converters required to adapt the standard RTU electronic circuits to the input voltages of 120V ac and 120V dc.

c. The 120V dc emergency battery supply for each substation RTU will be provided by CTA. Intermediate battery supply taps for the emergency dc supply will not be permitted. The 48V dc UPS System emergency battery supply for 8-hour capacity (at full configuration) and associated battery charger (with current limiting charging current feature) for each RTU shall be furnished, installed, and completely wired by the Contractor.

d. The Contractor shall be responsible for converting and distributing the dc power within the RTU cabinet as necessary to operate the specified RTU equipment.

e. The power supplies/converters shall be redundant in all RTUs with automatic switching capabilities such that failure of one converter shall not disrupt RTU operation. The power supplies/converters shall have the following characteristics:

i. Outputs shall be fully isolated from the inputs so that no ground can be imposed on the battery.
ii. Both inputs shall be fused and opened with a single on/off four pole single throw 4PST switch.
iii. Input shall meet IEEE SWC standard test (IEEE 37.90.1-2012).
iv. Adequate filtering shall be provided on the input such that any chopping noise from the converter is not imposed on the battery.
v. The chopping circuitry shall not produce an objectionable noise. It is desirable that the circuitry operates above the audible range, preferably 20 kHz or higher.
vi. Indicating lamps shall be provided which light only if converter output is energized.

f. Overvoltage and undervoltage protection shall be included on the outputs to prevent the microprocessor hardware from being damaged due to a single component failure in the converter, or from becoming unstable and causing false operation of control functions. Short circuit protection shall also be provided on the outputs.

g. The capacity of all power supplies and converters supplied shall be sufficient to handle expansion of the RTU to its full capacity of points as specified in Appendix "A.”

13. Terminal Blocks

a. All external wiring interfacing with the RTU cabinet shall terminate on easily accessible interposing terminal blocks within the RTU cabinet. This wiring shall include, but not be limited to, emergency power supply wiring, supervision contacts, interposing relay contacts, telemeter points and line wires. Terminal block shall be TRW Cinch Jones Series 141 dual barrier style or approved equal.

b. Self-extinguishing white vinyl marking strips shall be included on all interposing terminal blocks. All terminals to which battery or other high voltages are to be connected shall be provided with protective covers. All terminal blocks shall be labeled and have corresponding identification on unit schematic prints.

14. 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.

15. 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.

16. Components

a. To the greatest extent possible, all components used in the SCADA system shall be high quality solid-state silicon type devices suitable for the application and sufficiently derated for long life.

b. Proper mounting shall be employed for all components on printed circuit boards to prevent damage from shipping and vibration encountered in rail "right-of-way" environments.

c. Circuit boards and their components shall be suitably protected from dampness and corrosion common to the exterior environments.

17. Construction/Packaging/Labeling

a. In addition to general quality workmanship the following shall be implemented:

i. All plug-in printed circuit cards shall be keyed to prevent damage to the RTU or devices connected to the RTU through improper connection.
ii. Gold plated contacts shall be used on all printed circuit board and other multi-pin connectors.
iii. All printed circuit boards shall be made of glass-epoxy material.
iv. Each printed circuit board and all subassemblies shall be serial numbered to uniquely identify them for warranty.
v. All nameplates for cabinets, panels, components, relays, fuse blocks, switches and terminal blocks (except terminal block numbering strips) shall be plastic, utilize white printing on a black background, and shall match those on existing CTA SCADA equipment. All nameplates shall meet the approval of the CTA Project Manager.
vi. All terminal blocks, rows and/or columns shall be suitably and clearly labeled by the Contractor using standard methods.
vii. All plug in devices/cards shall employ a positive locking design to prevent loosening from vibration.
viii. All internal components shall be labeled and referenced to the internal schematic diagram.
ix. Conformal coating.

18. RTU Capacity and Expansion

a. The point capacity of each RTU shall be as defined in Appendix "A."

b. Since more input/output points may be required in the future, modularity is extremely important. Initially, only those panels, input/output and point cards that are needed to fulfill the specified point counts including designated spares as listed in Appendix "A" shall be installed. However, space and any necessary pre-wiring shall be provided such that additional points can be added by plugging in additional circuit boards/relay panels and installing additional pre-constructed plug-in cables. All spare wiring capacity shall be tested to verify that it is correct.

c. All supplied power supplies and related hardware shall be sized to accommodate the maximum hardware configuration possible for each RTU.

19. RTU Enclosure

a. General

i. All cabinets shall be designed to incorporate necessary bracing to assure the rigidity of the cabinet including the door.
ii. All cabinet doors shall be furnished with suitable handles and 3-point latching mechanisms. All door locks shall be keyed to match existing SCADA RTU cabinet locks. Cabinets shall be provided with provisions for a CTA supplied 5/8" padlock.
iii. All enclosures shall utilize interior mounting panels for the mounting of all RTU components such as circuit boards and relays. Components shall not be mounted directly to the interior of RTU cabinets. All mounting holes shall be tapped. Nuts behind panel are not permitted.
iv. All enclosures shall have a print pocket attached to the door for the storage of prints and point assignment charts.
v. Enclosures shall be constructed such that removal of the enclosure from its mounts or the removal of any internal components from the RTU shall not require the removal of any interior mounting panel.
vi. The enclosure shall be of sufficient strength such that no supports external to the cabinets are required if the cabinets are securely fastened to the floor or vertically mounted on a stand.
vii. The enclosures shall have a rear mounting lip around entire perimeter of enclosure.
viii. Each enclosure shall have mounted on it a large, easily read, identification label corresponding to the location where the RTU will be installed. These shall match labels on existing CTA RTUs or shall be approved by Authority's Project Manager.
ix. The enclosure shall be equipped with suitable removable lifting eyes as required.
x. Suitable grounding braid shall electrically connect all portions of the enclosure together. A ground lug capable of accommodating up to a #8 AWG stranded grounding cable shall be provided on each enclosure.
xi. All enclosures shall be equipped with a door stop kit which will permit door to be opened at 180 degree.
xii. The maximum dimensions for the RTU cabinets shall be 90 inches high, 36 inches wide, and 20 inches.

b. Standard NEMA 12 (dust-tight and drip tight), free standing enclosures are required for the RTUs. Enclosures shall be of highest quality construction, both in material and workmanship and shall be suitable terminal block within the enclosure for terminating all field wiring. The enclosures shall be arranged for top and bottom cable entry. The enclosures shall be made of not less than 1/8 inch thick corrosion resisting sheet metal, “parkerized” or “bonderized” and coated with two (2) coats of enamel on all surfaces. Color shall be ASA #61 light gray. Door surface shall incorporate bracing to prevent door buckling or warpage.

c. All enclosures shall be floor mounted and shall be installed on maple wood blocks covered by a sheet of GP03 Glastic to isolate the enclosures from ground.

20. Environmental

a. All RTUs will be installed in substations. They will be subjected to temperatures, moisture, and vibration common to these locations.

b. The RTUs are to operate reliably, without adjustments, in environments with an ambient temperature range of -30 to +60 degrees Celsius in enclosure and relative humidity range of 15 to 95 percent.

c. All RTUs shall have heaters thermostatically controlled to maintain a minimum of +5 degree Celsius in a -30 degree Celsius ambient to keep moisture inside the enclosure to a minimum. The heaters shall be equipped with an adjustable high temperature cut out (thermostat) to prevent over temperature conditions inside the RTUs. These RTUs shall also be equipped with necessary vibration and shock protection (at 100dB) to guard against vibrations encountered in the above described environments.

21. Protection

a. 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.

22. Others

a. All RTUs shall have a switch able interior AC light and dual duplex socket available mounted inside the RTU cubicle

PART 3 EXECUTION

3.01 INSPECTION, TEST AND AVAILABILITY

A. Inspection

1. The Authority's representatives and agents shall have free entry into the shops of the Contractor at all reasonable times while fabrication and testing of the specified equipment is being performed. The Contractor shall provide the Authority's inspector, free of charge, all reasonable cilities necessary to satisfy the Authority's inspector that the material in fabrication is in accordance with the specifications. However, such inspection by the Authority's inspector should not relieve the Contractor from responsibility for furnishing material and equipment to conform to the requirements of

the Works Statement nor invalidate any claim which the Authority may make because of defective or unsatisfactory material or equipment.

B. Factory Acceptance Test Procedure Documents

1. Prior to shipment of the SCADA system, a thorough, formal, integrated Factory Test shall be conducted with at least the Authority's representatives and Project Manager or the designated representatives in attendance. The Contractor will notify the Authority in writing four (4) weeks prior to the test, that the system, in the opinion of the Contractor, is ready for the formal Factory Acceptance Test. The Factory Acceptance Test Procedure Document should follow a standard test format and be submitted to the Authority at least sixty (60) days prior to the scheduled formal Factory Acceptance Test, for review and approval. The formal Factory Acceptance Test shall not take place until the Factory Acceptance Procedures Document has been approved by the Authority's Project Manager.

2. The Factory Acceptance Test Procedure Document shall at a minimum:

   a. Contain the ID number, name and description of each piece of equipment to be tested.

   b. List the logical step-by-step procedure with expected response at each step and provides space for recording of actual results.

   c. Provide spaces for approval of each test.

   d. Contain checkpoints at critical points in the logic.

   e. Generally be structured such that simpler tests are run first.

   f. Be written such that it can be used by Purchaser during field testing.

   g. Describe any steps necessary to simulate inputs required by the test.

3. The Contractor shall provide an overall test schedule (to be approved by the Authority) that includes time for unstructured testing.

C. Factory Acceptance Test

1. All equipment specified herein shall be given factory tests consisting of individual operating tests and dielectric tests in accordance with applicable Institute of Electrical and Electronic Engineers Standards. Devices requiring calibration shall be carefully adjusted to the specified settings. RTUs will undergo complete function tests using a simulator as the master. All points shall be given complete control and indication tests, including telemetering. Tests shall be run simulating the following cases of line conditions existing between the master and the remote units. The line conditions shall apply to both pairs of lines interconnecting the units.

   a. Two-wired modem communication:

      i. Maximum Line Resistance - 3000 Ohms Line (loop resistance)
      ii. Maximum Line - Line Capacitance - 1.1 microfarads
      iii. Maximum Line - Ground Capacitance - 0.11 microfarads (each line)

   b. Two-wired modem communication:

i. Minimum Line Resistance - 0 Ohms
ii. Minimum Line - Line Capacitance - 0 microfarads
iii. Minimum Line - Ground Capacitance - 0 microfarads (each line)

c. Two-wired modem communication:

i. Zero Ohms with respect to ground on one of the lines.

d. RS-232 serial communication:

i. 1200, 2400, 4800, 9600, or 19,200 bauds.

e. Ethernet IEEE 802.3 communication:

i. 10BaseT, 100baseTX, and 100baseFX.

2. All tests shall be witnessed by the Authority's representatives.

3. The simulator connected as a master station and all RTUs shall be included in the Factory Acceptance Test.

4. The testing shall exercise every conceivable function of the SCADA system and shall include, but not be limited to, the following:

a. Demonstration that all peripheral hardware and software are operational.

b. Simulation of alarms including multiple simultaneous status changes. Simulated or actual inputs shall be provided to each RTU.

c. Demonstration of the control operation of each control output with proper lights or other indications to confirm the control operations.

d. Simulation of RTU noise and transient conditions, verifying that erroneous indications and operations do not occur, and no damage to equipment results. Demonstration of all man-machine interface functions.

e. All displays, logs, operator/user procedures, and points must be shown to be implemented.

f. Creation and handling of ALL possible error and device failure conditions.

g. Demonstration of analog input/output accuracy, utilizing equipment with current calibration validation.

h. Demonstration of configuration switching.

i. Demonstration of all special applications functions including simultaneous tripping and simultaneous closure, emergency closure [if equipped], report generation and logging.

j. Demonstration of Central Processing Unit (CPU) loading and efficiency criteria.

k. Demonstration of operation of RTUs and SCADA simulation equipment under specified environmental conditions.

l. Demonstration of the performance of the RTUs, including:

i. Proper cabling
ii. Proper card counts
iii. Accuracy
iv. IEEE SWC on all inputs/outputs (IEEE C37.90.1-2012)
v. Proper operation of all input and output functions
vi. Proper link-up with data base (point-to-point verification)

m. Verification of the correct inventory of hardware.

n. Demonstration of all hardware and software diagnostic capabilities.

o. Verification that the required expansion capabilities are available.

p. After the successful completion of all the above tests, a 100-hour continuous operation of the SCADA system without loss of any function, without any hardware or software failure, and without any failover (except manual failover), during which time actual system operation is simulated and the man-machine interface is exercised to determine possible weaknesses. Unstructured time for testing by the Authority's representatives shall be included during this test. No software "patches" or changes will be allowed to bypass failed modules during the test.

5. Discrepancies found during the factory test shall be documented and maintained in a record file. The subsequent correction shall be described and proper operation be verified by representatives of the Authority and the Contractor. Faulty and/or incorrect operation of major functions (major discrepancies) may, at the discretion of Authority's Project Manager or his designated representative, be cause for the suspension or restarting of the entire test pending the correction of the problem. Minor discrepancies noted shall be corrected and retested. The Authority may request that other modules hat may be impacted by the correction be retested also.

6. The Factory Acceptance Test will be considered successfully completed only when ALL the RTUs have passed ALL the factory tests. The system shall not be shipped until the completion of the Factory Acceptance Test is certified by the Authority's Project Manager or his designated representative. Delay in the shipment of the system due to failure in passing the Factory Acceptance Test shall NOT be considered as an unavoidable delay.

D. 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.

E. 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 SHIPMENT

A. Master Station Expansion Hardware

1. The Master Station Expansion Hardware shall be assembled, tested at the factory, and shipped as a single unit, where possible. The contractor/manufacturer shall work to minimize the installation/assembly and testing necessary on Authority property.

B. RTU Hardware

1. All RTUs hardware shall have been assembled, wired, and tested at the factory before shipping

3.03 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. SCADA Master Station

1. Master Station Expansion Hardware

a. Master Station expansion hardware shall be installed and configured by the Contractor. Contractor shall provide hardware and RTU communication and configuration to the CTA so the CTA can configure, install, and test all furnished equipment

2. Master Station Expansion Software

a. Master Station expansion software shall be installed and configured by the Contractor. Contractor shall provide RTU communication and configuration so the CTA can configure, install, and test Master to RTU to Master communication.

b. SCADA RTU operating display and database point configuration will be prepared by the CTA.

C. Remote Terminal Unit Interconnection Cables

1. The modem communication cable between RTU and local communication terminal shall be #18 AWG individually shielded twisted four (4) pairs stranded tinned copper conductors, each with a stranded tinned copper #18 AWG drain wire and aluminum-polyester shield, EPR insulated, thermoset, flame resistance, low smoke non-halogen cross-linked polyolefin jacket cable, rated at 600V 90 degree UL listed.

2. SCADA copper ethernet network communication cable between RTU and local network equipment shall be two (2) 4-pairs CAT 5 shielded twisted-pair cables with RJ-45 EIA-568-B connectors. Contractor must verify with Authority Project Engineer to confirm network cable requirement.

3. SCADA fiber ethernet network communication cable between RTU and local network equipment shall be a minimum of eight (8) connectorized fiber cable. Contractor must verify with Authority Project Engineer to confirm fiber cable type and well as connector type for use in this project.

4. 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.

5. 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.

6. 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.

3.04 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.

B. During the Warranty Period, the Contractor shall make available one (1) specialist who shall be on call at all times with a twenty four hour maximum response time. The Contractor shall replace or repair all defective parts and shall have prime responsibility for keeping the System fully operational. In addition, any part which is made obsolete by redesign or modification shall be replaced (in the System and in the support parts stock) at no additional cost to the Authority.

3.05 SUPPORT PARTS

A. The Contractor shall furnish a complete stock of support parts sufficient to maintain the system availability specified.

1. SCADA Master Station

   a. Provide a minimum of 10% of the individual SCADA master expansion modules as supplied under this contract for the SCADA RTU field communication interface between the SCADA master CPU and field RTU communication terminations.

2. Remote Terminal Unit

   a. As a minimum, there shall be 10% (10% of each total module/component/item supplied for the RTUs) support parts provided for all module and/or component supplied for this project. These shall include but not limited to complete Racks, CPU Modules, Modem Modules, Control Modules, Analog Modules, Status Modules, Interface Modules, Interconnection Cables, Power Supplies, and Ground Detectors.

   b. A support parts cross-reference list (referenced to the subsystem module, location and circuit card) shall be provided for ease in replacement part identification of individual system components.

   c. Standard identification numbers used in the electronic industry shall be used in the identification of components at the circuit board level.

   d. Support parts shall be available for a period of at least ten (10) years from the date of final system and field acceptance by the Authority.

3. Others

a. During the warranty period, the Contractor shall continually replenish the Authority's support parts stock as parts are used to replace defective ones, at no extra cost to the Authority. At the end of the warranty period, the support parts stock shall contain the complete set of support parts for which the Authority originally contracted with the exception of parts added to the System or parts made obsolete by redesign or modification.

b. In the latter case, the redesigned or modified part shall be maintained in the support parts stock (during the warranty period) in the same quantity as the part made obsolete at no extra cost to the Authority. Cards, modules, or electrical components not mounted on cards which have been added to the System, shall be added to the set of support parts at no extra cost to the Authority and maintained in sufficient quantity (during the warranty period) in order to achieve the 99.9% availability criterion.

3.06 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.

3.07 SCADA SYSTEM TEST SETS (SIMULATORS)

A. One (1) complete SCADA system test set (simulators) shall be furnished. Each set shall be capable of emulating either the master station or a remote terminal unit. The simulators shall have display and control facilities that allow the operator to trouble-shoot, monitor, and control all the components of the master-to-RTU and RTU-to-master on a step by step basis.

B. The test set shall enable the technician to completely check out an RTU before it is connected to the master station.

C. Modem shall be included with the capacity to utilize the test set on either side of the RTU modem.

D. IN AN EMERGENCY, the test set shall be capable of controlling an RTU from either the Dispatcher's office (via simulators modem, rs-232 port, or Ethernet communication) or at the remote station. If notebook computers are provided, each note book computer shall be 14 inches screen, professional grade to be approved by the Authority project manager.

E. Test points shall be provided within each RTU to facilitate trouble shooting of hardware and communication lines. These test points shall be located in convenient easy to access locations within each RTU.

F. Each SCADA test set shall be supplied with its own comprehensive manual(s) describing connection and operation of the test set.

3.08 TRAINING

A. The Contractor shall provide and include in the contract price on-site training for furnished SCADA equipment. 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.

3.09 HARDWARE MAINTENANCE -TWELVE (12) PERSONS

A. The Contractor shall provide a detailed two-day (2 days) 16-hour course for twelve (12) of CTA engineering and maintenance personnel covering every item of equipment furnished as part of this Specification. The Project Manager and his designated eleven (11) Hardware Technicians shall attend. The quality of instruction shall be such that the trainees will be able to troubleshoot both at the master station and remote RTUs and to maintain the system on a card replacement basis and to the Contractor's satisfaction in regard to the guarantee requirements.

APPENDIX - A

SUBSTATION CONTROL/ALARM/TELEMETERING

TABLE - A

RTU REMOTE TERMINAL NAME	Number Contact Inputs		Number Analog Inputs *		Number (2 State) Moment Outputs		Number (2 State) Latch Outputs	
	Initial	Ultimate	Initial	Ultimate	Initial	Ultimate	Initial	Ultimate
RTU Broadway Substation	64	96	36	48	32	32	1	2

- In addition to normal analog inputs, the RTU shall be provided with minimum 11 high-speed analog capture inputs.

REMOTE TERMINAL REQUIREMENTS

APPENDIX – A

SUBSTATION CONTROL/ALARM/TELEMETERING

TABLE - B

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
1	EMERGENCY CLOSE	X								X
2	RECTIFIER #1	X	X	X			X	X	X	
3	RECTIFIER #2	X	X	X			X	X	X	
4	RECTIFIER #3	X	X	X			X	X	X	
5	RECTIFIER #4	X	X	X			X	X	X	
6	AC LINE 1	X	X		X		X	X	X	
7	AC LINE 2	X	X		X		X	X	X	
8	AC BUS TIE 1-2	X	X					X	X	
9	DC BUS					X				
10	DC FEEDER #1	X	X			X	X	X	X	
11	DC FEEDER #2	X	X			X	X	X	X	
12	DC FEEDER #3	X	X			X	X	X	X	
13	DC FEEDER #4	X	X			X	X	X	X	
14	DC FEEDER #5	X	X			X	X	X	X	
15	DC FEEDER #6	X	X			X	X	X	X	
16	DC FEEDER #7	X	X			X	X	X	X	
17	DC FEEDER #8	X	X			X	X	X	X	
18	DC FEEDER #9	X	X			X	X	X	X	
19	DC FEEDER #10	X	X			X	X	X	X	
20	DC FEEDER #11	X	X			X	X	X	X	
21	DC FEEDER #12	X	X			X	X	X	X	
22	RECTIFIER #1 AC BKR							X	X	
23	RECTIFIER #1 DC BKR							X	X	
24	RECTIFIER #2 AC BKR							X	X	
25	RECTIFIER #2 DC BKR							X	X	
26	RECTIFIER #3 AC BKR							X	X	
27	RECTIFIER #3 DC BKR							X	X	
28	RECTIFIER #4 AC BKR							X	X	

APPENDIX – A

SUBSTATION CONTROL/ALARM/TELEMETERING

TABLE - B

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
29	RECTIFIER #4 DC BKR							X	X	
30	SPARE	X	X			X	X	X	X	
31	SPARE	X	X			X	X	X	X	
32	SPARE	X	X			X	X	X	X	
33	SPARE	X	X			X	X	X	X	
34	SPARE	X	X			X	X	X	X	
35	SPARE	X	X			X	X	X	X	
36	SPARE	X	X			X	X	X	X	
37	SPARE	X	X			X	X	X	X	
38	SPARE	X	X			X	X	X	X	
39	SPARE	X	X			X	X	X	X	
40	SPARE	X	X			X	X	X	X	

SUBSTATION STATUS

TABLE – C

STATUS UNIT NUMBER	AT MASTER STATION	AT RTU	
	FUNCTION	CONTACT	
		a(A)	b(A1)
(41)	Emergency Close	X	
42	Door Alarm		X
43	174 Station Alarm		X
44	Remote Station Ground		X
45	243 Supervisory Switch Local		X
46	127 Loss of DC Control Power		X
47	164X DC Switchgear Grounded		X
48	237B Loss of Backup Supply		X
49	26TH High Room Temperature		X
50	26TL Low Room Temperature		X
51	27BC Battery Charger Failure		X
52	283 Power Transfer Relay On		X
53	63W Sump Well High Water		X
54	83-1 Transfer Switch #1 in Emergency		X
55	83-2 Transfer Switch #2 in Emergency		X
56	AF Air Filter Run out		X
57	164C DC Switchgear Structure Hot		X
58	SD Smoke Detector		X
59	27B Battery Failure		X
60	SPARE		X
61	SPARE		X
62	SPARE		X
63	SPARE		X
64	SPARE		X
65	SPARE		X
66	SPARE		X
67	SPARE		X
68	SPARE		X
69	SPARE		X

APPENDIX – A

SUBSTATION STATUS

TABLE – C (CONT')

STATUS UNIT NUMBER	AT MASTER STATION	AT RTU	
	FUNCTION	CONTACT	
		a(A)	b(A1)
70	SPARE		X
71	SPARE		X
72	SPARE		X
73	SPARE		X
74	SPARE		X
75	SPARE		X
76	SPARE		X
77	SPARE		X
78	SPARE		X
79	SPARE		X
80	SPARE		X

SUBSTATION SCADA LOGIC/INDICATION

TABLE – D

AC LINE, AC TIE AND RECTIFIER AC & DC BREAKERS

A	A1	INDICATION	DESCRIPTION
0	0	R/G	LOCAL/ALARM
0	1	G	OPEN
1	0	R/G	ILLEGAL
1	1	R	CLOSED

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

RECTIFIER LOCK-OUT

A	A1	INDICATION	DESCRIPTION
0	0	R/G	LOCAL
0	1	G	LOCK-OUT
1	0	B	ALARM
1	1	R	NORMAL

LEGEND
A = AMBER
B = BLUE
G = GREEN
R = RED

END OF SECTION

SECTION 34 21 80
TRACTION POWER MAINTENANCE EQUIPMENT

PART 1 GENERAL

1.01 DESCRIPTION

A. This section specifies requirements for furnishing and installing miscellaneous maintenance equipment for Broadway Substation.

B. If color of finish is not designated, the Authority will select from standard colors or finishes available.

C. Comply also with requirements of the Contract Drawings and other specification sections.

1.02 SUBMITTALS

A. Submit products data for each item specified including brochures, samples and manufacturers' standard finishes for approval by the Authority.

1.03 DELIVERY, STORAGE, AND HANDLING

A. All maintenance equipment and accessories shall be adequately protected during delivery to prevent scratches, stains, discoloration, or other causes. Damage to any surface during fabrication, handling, shipment, storage, and installation shall be remedied by the Contractor at Contractor's own expense.

PART 2 PRODUCTS

2.01 MAINTENANCE EQUIPMENT

A. One (1) 24 foot, fiberglass extension ladder, 300 lb capacity, extra heavy duty with oversized cast aluminum swivel safety shoes with thick rubber tread. Extension ladder shall be similar to "Louisville" Type 1A, FE 2200 Series.

B. One (1) each 4ft., 6ft., 8ft., 10 ft., & 12 ft. fiberglass scissors type ladders. 300 lb capacity, extra heavy duty, extra wide rubber tread safety shoes. Scissors type ladders shall be similar to "Louisville" fiberglass big foot 8057T7 series.

C. Two (2) rags and sweeping compound cans. 21 gallon steel cans with foot operated covers, 18 d" O.D. x 23 7/16 " H, similar to "Justrite" model no. 9-700.

D. One (1) 30 gal. capacity salt drum. Fiber dry material drum with steel cover 19d" body dia. x 27" H, similar to "Justrite" No. 4142T3.

E. One (1) snow thrower complete with all attachments, similar to "Toro" Model No. 521.

F. One (1) power lawn mower with 20" cut, 3.5-horse power and side grass catcher, similar to "Toro".

G. One (1) voltage detector and current tracer. Detector for 30-122,000 volts. Amprobe Model TIC 300 Pro non contact, AC volt detector with carrying case. Accessories:

1. One (1) 48" Amprobe Hot Stick for voltages up to 46KV, Model TIC410A

H. Two (2) pairs of linemen's seamless dielectric rubber gloves meeting NFPA-70E Standard OSHA regulations for protection against electrical shock and arc flash hazard, Class 3, 16" long, similar to Salisbury SK-a00. Two (2) pairs leather protectors to be worn over gloves. 13" long for glove class 3, 16" long similar to Salisbury ILP series. Glove and leather protectors' size to be determined by the Authority.

I. Two (2) hard hats meeting NFPA-70E Standard and OSHA regulations for protection against electrical shock and arc flash hazard, consisting of the following components:

1. Helmet: Protective, HI-VIS yellow, MSA "V-GARD" 2 reflective strips, custom logo, adjustable ratchet suspension (MSA FAS-TRAC), slotted, standard size, complies with ANSI Z89.1-1997,type I, class E.

2. Faceshield: Arc shield visor with chin guard,10 CAL ATPV rating, tinted green, for use with MSA faceshield helmet bracket (CTA Item 1952401) and MSA VGARD standard CTA hardhat.

3. Frame: Face shield, for attachment of faceshield to MSA V Gard hard hats. For use with faceshield Item # 1959211.

J. Two (2) 120 volt ac substation wall clocks with quartz movement. 12" diameter.

K. Two (2) insulating arc suppression blankets type 1/natural rubber, class 2/20 KV. Similar to "Salisbury" EDP/cat. No. 0202 300, black color.

L. Two (2) protective jackets meeting NFPA-70E Standard and OSHA regulations for protection against electrical shock and arc flash hazard similar to Salisbury 11CAL/cm^2 hooded jacket Cat #JSHV1132BL-L with overpants Cat #ACP1130Bl-L, in large size.

M. If FBK type breakers to provide breaker bench.

N. Dust cover for spare DC Feeder breaker.

O. Provide portable gantry crane by Spanco with Standard "A" Series American I-Beam incorporated in design or approved equal. The gantry range should be up to 1-ton capacity with aluminum construction and overall span of ten feet. Manual 1-ton chain hoist shall be provided with 20 foot lift and storage container. Span kit shall be provided to shorten the crane for travel down narrow aisles. Provide manual 1-ton geared trolley for precise control. Caster wheels shall have brakes and four-position swivel locks.

P. Portable Air Compressor:

1. The Contractor shall furnish portable air compressors at each substation. The compressor shall be equipped with oil lubricated pump, regulator gauge, low oil level protection; automatic condensate trap; totally enclosed belt guard; dual control, including pressure switch; and hose connections. The compressor shall be complete with spring vibration isolators.

2. The air compressors shall be rated at 7.0 cfm minimum at 90-psig discharge. The tank shall be ASME coded 20 gallon capacity.

3. The compressor shall be equipped with 30 feet of industrial grade hose.

4. The compressor shall be equipped with a safety air gun. It shall have an adjustable air volume knob and a hanging hook.

Q. Wet/Dry Vacuum Cleaner:

1. The Contractor shall furnish a 4 gallon, 5 horse power wet/dry vacuum cleaner similar to Craftsman Model 17612.

R. Battery Conductance Tester:

1. One (1) Midtrinics Model CMA7000 Battery Conductance Test System complete with dual contact clamps, dual contact probes, A087 printer with A090 power supply, including an extra battery, an extra charger and a carrying case.

S. Remote Racking Device:

1. One (1) Remote Racking Device for 15kV ac medium voltage breakers.

PART 3 EXECUTION

3.01 INSTALLATION

A. Prior to placing the substation in service, all maintenance equipment and accessories shall be assembled and placed at the Authority's direction ready for use.

B. Install when required maintenance equipment and accessories to comply with manufacturer's instructions and recommendations.

C. Arrange deliveries to provide continuity of installation for any phase of work.

3.02 CLEANING AND ADJUSTING

A. Adjust parts to proper operational condition prior to completion of project.

END OF SECTION

SECTION 34 21 90
TRACTION POWER SUBSTATION CONTROLS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and 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 controls as specified in this specification and testing of the completed work; and all other construction reasonably required to provide a complete workmanlike job.

B. Any additional fittings, conduits or specialties and other appurtenances 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, 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.

D. All materials shall be new and the best of their respective kinds. The use of other than "prime" grades will not be accepted

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 for the required installation.

F. Related Sections: The following section contains requirements that relate to this section.

1. Section 34 21 65 Basic Electrical Materials and Methods Traction Power

2. Section 28 31 10 Fire Detection and Alarm

1.03 SUBMITTALS

A. The Contractor shall submit product data, brochures, cuts, specifications, shop drawings, conduit layouts, installation drawings, diagrams, schedules and samples in accordance with Division 01 Section, Submittals, and supplementary requirements as stated under the sections of these Specifications for all the materials and construction referred to in this section.

1. All dimensions and conditions shall be field verified at the project site and coordinated with the work of all other trades.

2. Conduit and box layout shall indicate obstructions that are to be avoided.

3. Conduits and boxes shall not be exposed in finished areas unless indicated or approved otherwise.

B. See Section 34 21 01, General Requirements for Traction Power Equipment for additional submittal requirements.

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 HEATING AND VENTILATING CONTROLS

A. The substation is heated by gas.

B. Each heating and ventilating system shall have its own temperature control panel. Each temperature control panel shall be connected to its own damper motors, thermostats, and smoke detectors.

C. One (1) attended/unattended selector switch shall be provided for the heating and ventilating system.

D. The Contractor shall furnish and install all materials including temperature control panels, control devices, conduits and cables and furnish all testing services required to complete the installation of the heating and ventilating system as specified herein.

E. This section covers wiring to be furnished and installed to provide electrical interconnections between all equipment and control devices specified in Division 26 of these specifications.

F. Major components of the heating and ventilating system consists of: temperature control panel, building air supply filter unit, exhaust fans, washroom heater, thermostats and dampers.

G. Operation of each heating and ventilating system shall be as follows:

1. Ventilation Control:

a. A rise in temperature above the set point of T1 and T2 shall open its associated inlet and back draft dampers. The end switches of inlet dampers will turn off the gas heaters when the dampers are open. The end switches of back draft dampers will turn-on the exhaust fans when the dampers are open.

2. Media Control:

a. Media (Filter) shall be controlled manually.

3. Heating Control:

a. When the selector switch is in the "ATTENDED" position, a drop in room temperature below the 70º F set point of room thermostat T3 shall cause the T3 contact to close and turn the heaters on as required to hold room temperature. At the same time the ceiling fans will be engaged for supplemental warm air circulation, thus sealing the control circuit and leaving fans operating until the "ATTENDED/UNATTENDED" switch turned to UNATTENDED POSITION.
b. When the selector switch is in the "UNATTENDED position, a drop in room temperature below the 55º F set point of room thermostat T4 shall cause the T4 contact to close and turn on the heaters.
c. An overriding adjustable time clock control shall be furnished and installed to automatically turn off the heaters and the hot water heater during the weekday morning and evening peak traction load periods. The 24 hour time switch device for heat time cloak shall be wall mounted type TORK-T7220 or approved equal.
d. Toilet room heater will be controlled by independent thermostat T6.
e. Set points for the thermostats are:

Thermostat	Temperature
T1	78^0 F
T2	82^0 F
T3	70^0 F
T4	55^0 F
T6	65^0 F

H. 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.

I. Miscellaneous Heater Contactors:

2. The Contractor shall furnish, install and wire, for each heater, 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.

J. Starter Overload Relay Heaters:

1. The Contractor shall select, furnish and install thermal overload relay heaters for motor-amperes given on motor nameplates. 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.

K. Heating system shall maintain 55 degrees F inside the substation when outside ambient temperature is -20 degrees F. Ventilation system shall maintain inside temperature at no more than 5 degrees F above outside ambient temperature.

L. The control equipment and devices shall be as follows:

1. Temperature Control Panels:

   a. Contractor shall furnish and install the temperature control panels for the heating and ventilating system. The panel shall have all devices, as indicated, mounted and interconnected with wiring to terminal blocks.

2. The following major devices shall be furnished and mounted in each temperature control panel:

   a. One (1) Lot of Terminal Blocks:

      1) Terminal blocks shall be suitable for the size of wire, voltage and current rating of the conductor being terminated. Blocks shall include pressure (clamp) type terminals, barriers, and white marking strip for circuit identification. The terminal blocks used shall include a minimum of twenty percent spare terminals.

   b. Miscellaneous Requirements:

      1) Interconnecting wiring shall be of type "SIS", 600V rating, size 14 AWG minimum, stranded copper.
      2) Panel construction shall be of NEMA 12 type enclosure requirements with continuous hinged cover (minimum size 30 inches H x 24 inches W x 8 inches D).
      3) Panel shall be made up from No. 12 gauge steel. Panel shall be finished in gray prime outside over phosphatized surfaces.
      4) Each panel shall be provided with removable No. 12 gauge steel panel mounted on collar studs. Panel shall be given one prime coat over phosphatized surface and be finished with one coat of white enamel.

3. "ATTENDED - UNATTENDED" Selector Switches:

   a. "ATTENDED-UNATTENDED" Selector switch shall be furnished for the substation. The selector switch shall be oil-tight, two position-maintained position type, complete with four NO-NC contacts rated 120V AC-10A continuous (NEMA rating designation A600), housed in a NEMA 1 enclosure.

4. The ranges and operation of control components for each heating and ventilating system shall be as follows:

   a. Thermostats T1 and T2 shall have an operating range of 70 degrees F to 100 degrees F and T4 and T6 shall have an operating range of 55 degrees F to 85 degrees F, complete with "make" type contact.

b. Alarm thermostat (T5) shall have an operating range from 50 degrees F to 150 degrees F contacts maintained closed in its range and wired open supervisory "station alarm" circuits when limits are exceeded.

c. Damper motors shall be of the two position type with spring return rated at 24 volts ac and completed with end switches as required.

2.02 FIRE ALARM

A. The fire alarm system shall be installed in accordance with section 28 31 10 Fire Detection and Alarm.

B. The fire alarm panel shall be provided with one form A trouble contact, one form A alarm contact and three form C auxiliary alarm contacts. The alarm panel contacts shall be wired with one set of form A contacts to a local alarm (Device 130) for substation alarm signal, one from A smoke detector trouble and one form C to the supervisory cabinet (RTU), one form C contact for the exhaust fan shutdown, and one form C contact for the attended/unattended circuit. The Contractor shall furnish and install an indoor junction box with terminal block and conduit and wiring for the alarm circuit.

2.03 ANNUNCIATOR REMOTE HORNS

A. A remote horn shall be installed. It will sound if any annunciator point (except the smoke detectors) in rectifiers and in dc switchgear line-up is actuated.

PART - 3 EXECUTIONS

3.01 INSTALLATIONS

A. General:

1. Conduit openings as required for installation of all conduits shall be provided.

2. Smoke detectors will not be located over the switchgear.

3. 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.

B. Control Panels:

1. The control panels shall be supported and mounted away from the wall with "C" shaped galvanized steel channel. The minimum separation between the equipment and the wall shall be on half inch.

a. Equipment shall be functionally tested after all indicated loads are in place and connected.

b. Test shall be for all loads operating normally and shall be witnessed by the Authority.

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 General and Special Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

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 the 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

G. Related Sections

1. The following sections contain requirements that relates to this Section.

   a. 34 24 20 Traction Power Contact Rail

   b. 34 24 22 Contact Rail Insulated Chairs Fiberglass

   c. 34 24 23 Contact Rail Bonding

   d. 34 24 24 Contact Rail Anchors

   e. 34 24 30 Rail Connections And Running Rail Bonding

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.

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 01 33 00, Submittal Procedures, 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.

END OF SECTION

SECTION 34 24 23
CONTACT RAIL BONDING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Special Conditions and Division 1 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.

C. Related Sections: The following sections contain requirements that relate to this section.

1. Section 34 21 61, General Provisions Traction Power.
2. Section 34 24 20, 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.

END OF SECTION