CITY OF AUSTIN
Austin Water

PROJECT MANUAL
Contract Documents and Technical Specifications

VOLUME 3 of 5

South Austin Regional Wastewater Treatment Plant Electrical Substation No. 1 Replacement Project

C.I.P. PROJECT NUMBER: 3333.032
SOLICITATION NUMBER: CLMC739

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Austin Water

South Austin Regional Wastewater Treatment Plant
Electrical Substation No. 1 Replacement Project

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CITY OF AUSTIN
Austin Water

South Austin Regional Wastewater Treatment Plant
Electrical Substation No. 1 Replacement Project

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Austin Water

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C.I.P. PROJECT NUMBER: 3333.032
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7 October 2019

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END

SECTION 16044

15KV METAL CLAD SWITCHGEAR AND
15KV MEDIUM VOLTAGE OVERHEAD BUS DUCTS

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required to provide, and make ready for operation, two (2) INDOOR 15kV Metal-Clad Switchgears (in combination with 15kV Vacuum Circuit Breakers), and with connecting 15kV overhead bus duct system (totally enclosed bus duct/tie bus duct, complete with overhead bus duct support system), as specified herein. Both Metal-Clad Switchgears and the connecting overhead bus duct system shall be used as the main 15kV (voltage class) power distribution assemblies serving the 15kV medium voltage sub-distribution system (in its entirety) of the South Austin Regional Wastewater Treatment Plant in Austin, Texas.

1. The Switchgears and the connecting overhead bus duct system (tie-bus) shall be installed in a climate controlled electrical building identified on the PLANS as Substation No. 1.

2. The switchgears are tagged "SUB1-SWGR-100" and "SUB1-SWGR-200" on the PLANS

B. Furnish all labor, materials, equipment and incidentals required to rehabilitate existing substation class transformers to add new air terminal chambers on the primary and secondary side to facilitate termination of wire onto the primary and secondary side of the transformers, as further described in these specifications and shown on the drawings. The existing transformers presently have bus duct connection on the primary and secondary side. All existing transformer rehabilitation shall be performed on site at the South Austin Regional Wastewater Treatment Plant in Austin, Texas.

C. The bussing of all Switchgears is intended to be designed as such to allow direct/coupling with future feeder breaker sections added to the Switchgears.

D. The arrangement and dimensions of the Metal-Clad Switchgears and the 15kV overhead bussing shall be as shown on the PLANS. Design, arrangement and physical dimensions of the Switchgears and the 15kV overhead bus duct system are based on information provided by Square D Corporation, Eaton Corporation, and General Electric G.E. corporation. Any other arrangement will not be accepted without prior approval of the owner/engineer.

E. All parts, components, wiring, etc. within each section of each Metal-Clad Switchgear, and the 15kV overhead bus duct system shall be installed/assembled at the factory. No field work shall be involved besides unloading, setting, connecting Switchgear bussing at point of split-shipping, connecting 15kV overhead bus duct system to the 15kV Switchgears, and testing/commissioning the entire assemblies (Switchgear and Switchgear bus duct assemblies).

1.02 RELATED REQUIREMENTS

A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.

B. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.

C. PLANS designate type, number, size, and rating of devices included in the Metal-Clad Switchgears, and the ratings of the 15kV overhead bus duct system.

D. Comply with the requirements of all sections in Division-16 of the Contract Specifications, PLANS, and the Contract Documents.

1.03 QUALITY ASSURANCE

A. The manufacturer of the Metal-Clad Switchgears shall also manufacture the majority of components and subsystems therein (i.e., vacuum circuit breakers, current transformers, potential transformers, etc.).

B. The manufacturer of the 15kV medium voltage overhead bus duct system shall be the same as the manufacturer of the 15kV Switchgears.

C. Furnish equipment meeting these specifications and manufactured by Square D Corporation, or, approved equal by Eaton Corporation, General Electric Company "G.E.", Asea Brown Boveri "ABB", or approved equal. All equipment, components, etc., shall be manufactured in the USA if at all possible.

D. 15kV medium voltage overhead bus duct system as manufactured by Cutler Hammer Corporation type Metal-Enclosed, or approved equal by General Electric Company "G.E.", Square-D Company, Asea Brown Boveri "ABB", or approved equal. All equipment, components, etc., shall be manufactured in the USA if at all possible.

E. Standardization: All like equipment shall be the product and assembly of the same manufacturer.

F. Standards: Comply with the latest requirements of NEMA, OSHA, NEC and all building codes. Design, construct, assemble and test in accordance with AISC, AISI, ASTM, NEMA , IEEE, U.L. and ANSI standards, including NEMA SG-4, 5, 6 and ANSI C37.0/0, .04, .06, .07, .09, .100, .11, .20, .20.2, .20.21, .55 and .24. The Metal-Clad Switchgears line-up and the Overhead Bus System, inclusive of the surge capacitors and lightning arresters installed in the Metal-Clad Switchgears, shall be U.L Listed.

1.04 SHOP DRAWING SUBMITTALS

A. Submit complete shop drawings and engineering data for review per the requirements of Section 01300 and Section 01730 of the Contract Specifications. At minimum, shop drawings data shall include the requirements of this Subsection of the Specifications.

B. As minimum, for each Metal-Clad Switchgear, submit:

1. Elementary wiring diagrams.

2. Detailed control wiring diagrams.

3. One-line and three-line diagrams.

4. Plan view and front elevation.

5. Bill of materials and catalog cut sheets on all materials.

6. Instrument panel arrangements.

7. Component arrangement on large scale drawing.

8. Sections through each unit showing location of C.T.'s, P.T.'s, bussing, breaker, load break switches, etc.

9. Complete CBA phase rotation drawings.

10. Outline drawings with weights and dimensions.

11. Certified copies of design test reports in addition to impulse withstand tests, heated continuous current tests, momentary current tests and interrupting tests reports.

12. Cubicle wiring diagrams showing terminal blocks and interconnecting wiring between equipment in the same relative position as the front view drawings.

13. Final as-built drawings and information for all items and components installed in the Switchgears.

14. Installation information including equipment anchorage provisions.

15. Seismic certification.

16. Key interlock scheme drawing and sequence of operations, where applicable.

17. Throat/connection assembly to the 15kV overhead bus-duct system for the two (2) 15kV Metal-Clad Switchgears.

18. Internal bus and tie breaker connection assembly between the two (2) 15kV Metal-Clad Switchgears.

C. As minimum, for the 15kV overhead bus duct system submit:

1. Isometric drawings showing overhead bus duct system interconnect with bussing assembly of each 15kV Switchgear, and showing overhead bus duct support system. This shall include dimensional elevation layout of each 15kV Switchgear, interconnect overhead bus duct layout and complete dimensioned elevations.

2. Complete layout, isometric, elevation, and cross sectional view drawings of the bus duct system and arrangement/layout with both 15kV Switchgears and the bus duct support system.

3. Bill of materials and catalog cut sheets on all materials used (including bus-duct support system).

D. Special Submittal Requirements:

1. All Switchgear layout drawings, cross sectional view drawings, wiring diagram drawings, Connection detail drawings, physical layout and detail drawings, etc. shall be developed electronically using AUTO-CAD Version 2007 software. Submittals shall include hard copies and electronic copies (of the quantity and format required by Section 01300 and 01730 of the Contract Specifications). All electronic drawing submittals shall be in AUTO-CAD Version 2007. This applies to all drawings requested in Subsection 1.04A, 1.04B, and 1.04C above, and any other manufacturer's product standard drawings required for submittal, and <u>ALL PRODUCT DRAWINGS TO BE SUBMITTED</u> for this project.

E. General: Items which are manufactured by others shall have the original manufacturer's name, catalog number and descriptive data.

F. Submit report of results of arc-flash hazard analysis, short circuit analysis, and coordination study described in Subsection 1.09, this Section of the Specifications, in accordance with the requirements of Section 01300 and Section 01730 of the Contract Specifications. Submit preliminary analysis report(s) for review. Include the following data:

1. Executive Summary discussion narrative

2. Short-Circuit and harmonic Methodology Analysis Results and Recommendations, with discussion narrative and device evaluation/comparison tables as applicable

3. Protective Device Coordination Methodology Analysis Results and Recommendations, with discussion narrative and device settings tables as applicable

4. Time-Current Coordination Graphs and Recommendations

5. Arc Flash Hazard Methodology Analysis Results and Recommendations with discussion narrative and tables as applicable. Include text of Arc Flash labels to be provided

6. One-line system diagram that shall be computer generated and will clearly identify individual equipment buses, bus numbers used in the analysis, cable and bus connections between the equipment, calculated maximum short-circuit current at each bus location, device numbers used in the time-current coordination analysis, and other information pertinent to the computer analysis. Use 11" x 17" sized paper, at minimum

7. Studies input data such as X/R ratio, cable impedance, and other information, in tabular form.

8. Additional information as required by subsection 1.09, this section of the Specifications.

1.05 OPERATION AND MAINTENANCE MANUALS

A. Submit operation and maintenance manuals per the requirements of Section 01730 of the Contract Specifications. At minimum, the manuals shall be inclusive of the requirements of this Subsection of the Specifications.

B. As minimum, the content of the Operations and Maintenance Manuals shall include:

1. Equipment function, normal operating characteristics and limiting conditions.

2. Assembly, installation, alignment, adjustment and checking instructions.

3. Operating instructions, for start-up, routine and normal operation, regulation and control, shutdown and emergency conditions.

4. Lubrication and maintenance instructions.

5. Guide to "troubleshooting".

6. Parts list and predicted life of parts subject to wear.

7. Outline, cross section and assembly drawings; engineering data; and wiring diagrams.

8. Test data and performance curves, where applicable.

9. Hard copy and electronic copy of the approved shop drawings (final versions) and the final as-built drawings.

10. Protective relays on-site setting, calibration and test reports.

11. Time delay and all transfer parameter settings of all control and transfer devices/components.

12. 15kV overhead bus duct system Certified Production Test Reports and Installation information.

13. Electronic copy of all protection and management relay device final settings on CD-ROM or Universal Serial Bus Flash Drive.

1.06 PRE-SUBMITTAL CONFERENCE

A. General:

1. Review the manner in which the contract requirements will be met prior to preparation of submittals. The Contractor, Engineer, Owner, and Manufacturer shall attend. Schedule, conduct, and arrange the conference within 90 calendar days after receipt of written notice to proceed work is given by the Owner

2. The Manufacturer shall present the following at the conference:

   a. List of protective relays/monitoring units and major accessories (timing relays, etc.) required and the brand that shall be used for each item

   b. Sample submittals from similar projects including the types of drawings/data specified herein.

1.07 DELIVERY, STORAGE AND HANDLING

A. The Contractor, and hence the Metal-Clad Switchgears supplier, shall be responsible for safety of the Metal-Clad Switchgears during storage, transporting and handling.

B. The Metal-Clad Switchgears shall have weatherproof non-porous extra heavy duty plastic covers at all times, until they are ready for test and start-up. Energize space heaters within the Metal-Clad Switchgears during storage and installation for humidity control.

C. Interior and exterior of the Metal-Clad Switchgears shall be kept clean at all times.

D. Unload and handle equipment by suitable methods that are recommended and approved by the manufacturer of the equipment.

E. Do not store equipment in direct contact with the ground.

F. Storage: All materials and equipment shall be environmentally protected and stored in climate controlled (temperature and humidity, etc.) environment. Furthermore, the building in which the material is to be located shall be fully dried in/sealed in, with wall sealant material applied, and sealant fumes dissipated from the atmosphere of the building prior to storage of any material. Contractor shall be fully responsible for provision of all power requirements and costs to maintain climate control for the material.

G. Additional project job site storage requirements: Upon delivery to the project site and prior to final installation, protect and store in accordance with the following:

   1. Environmentally protected and stored in climate controlled (temperature, humidity, and non-corrosive class) environment at the job site. Size, furnish and install temporary gaseous air scrubbers, air conditioners, and additional environmental control equipment complete with branch circuiting conduit/wire as required to maintain in a controlled environment at the following conditions:

      a. Ambient Dry Bulb Temperature:

         1) Minimum: 68 degrees Fahrenheit.

         2) Maximum: 85 degrees Fahrenheit.

      b. Ambient Relative Humidity: Maximum: 50%.

      c. Ambient Corrosion Level: International Society of Automation Class: G1

2. Every effort shall be made to provide all necessary electrical power connections ready for immediate connection to equipment upon arrival of equipment on jobsite.

3. Upon arrival of equipment onto job site, a maximum of one day shall be allowed for equipment to be left without to allow proper transition of power of equipment, especially any 120 VAC powered equipment, to ensure all air conditioning, heating, and gaseous air scrubbing equipment are fully operational with a maximum of a 10 minute down time during this transition of power.

4. Furnish and install replacement air scrubber media, air filters, etc., as required for proper operation of the environmental control equipment.

1.08 TOOLS AND SPARE PARTS

A. Furnish the following spare parts with the equipment for each Metal-Clad Switchgear in conformance with the specifications:

1. One (1) - Spare timing relay for each different type furnished and/or specified. A minimum of Five(5) relays shall be furnished.

2. Ten (10) - Spare control relay for each type used. Control relay shall be furnished complete with relay coils, Four (4) Normally Open (N.O.) contacts, Four (4) Normally Closed (N.C.) contacts, and shall be furnished with Relay Manufacturer's Transient Voltage Suppression Module.

3. One (1) - Maintenance handle for manually closing the medium voltage circuit breakers when not in housing and manually charging.

4. One (1) - Levering crank for moving the medium voltage circuit breaker between connected, test, and disconnected positions.

5. One (1) - Test cable for electrically operating the medium voltage circuit breakers outside the Metal-Clad Switchgear housings.

6. One (1) - Breakers test cabinet for testing the electrically operated medium voltage circuit breakers outside the housing of the Metal-Clad Switchgears.

7. One (1) - Test jumper for testing the medium voltage circuit breakers.

8. One (1) - Maintenance tool for the medium voltage circuit breakers.

9. One (1) – Breaker lifting yoke used for attachment to breaker for lifting breaker ON or OFF compartment rails.

10. One (1) – Portable lifting device for lifting the breakers ON or OFF the rails.

11. Two (2) – Electrical motor operated levering device with integral remote pendant control unit to allow levering of breaker between the connected, test, and disconnected positions from the pendant control unit located remotely from breaker cubicle.

12. One (1) – Dockable transport dolly for moving breaker about outside its compartment.

13. Four (4) – Feeder Management Relays complete with the Case (draw-out housing)

14. Two (2) – Substation Management Relays complete with all options and accessories

15. One (1) – Bus Differential Protection and Management Relay complete with the Case (draw-out housing).

16. Two (2) – Digital Synchronism Check Relay complete with the Case (draw-out housing).

17. Two (2) – Fuse pullers

18. Two (2) – Sets of fuses for each type and set used.

19. Ten (10) percent of the quantity of pilot lights for each color as hereinafter specified.

20. Ten (10) percent of the quantity of pilot light lamps/lenses for each color as hereinafter specified.

1.09 SPECIAL MANUFACTURER'S SERVICES

A. Furnish the services of a qualified, experienced, factory trained technical (non-sales type) representative to assist in the installation of the equipment. Include checking alignment of parts, wiring connections, operation of all parts (relays, circuit breakers, monitoring relays, power monitoring units, etc.), leveling and alignment of the Switchgear assemblies, torque check of horizontal bus connections between Sections of the Switchgears, interconnect wiring between Sections and within each Section of the Switchgears, overhead bus duct installation and alignment and space heater wiring, Switchgears space heater wiring, etc. Include time to correct and recheck any discrepancies which are discovered. Also include providing the Owner with a report certifying that the equipment was installed properly, tested and set in accordance with the manufacturer's recommendations, and is in satisfactory operating condition. Format and quantity of reports shall be per the requirements of Section 01300 and 01730 of the Contract Specifications.

B. Work in conjunction with the project's Process Instrumentation and Control System Contractor (PICS) during start-up of the equipment (Breaker operation, Breaker controls, and other sub-distribution equipment) to ensure that all Instrumentation and Control System interlocks between the Metal-Clad Switchgears and the Main Control Panel (MCP), designated on the PLANS as "SUB1-MCP-001", are in satisfactory operating condition to the Owner/Engineer.

C. Manufacturer's technical representative is to set, adjust and test all circuit breakers, protective relays, protective devices, etc., in the presence of an Owner representative. Additionally, the Manufacturer will select the characteristics of the protective devices that are most suitable for the system in providing proper protection and coordination. The settings will be based on coordination and short circuit studies performed in compliance with Section 16044 of the Specifications, paragraph 1.09 "Special Manufacturer's Services". Provide the OWNER with test report certified by the manufacturer. Include a record of all settings. Format and quantity of reports shall be per the requirements of Section 01300 and

Section 01730 of the Specifications. The Manufacturer shall furnish the protective device of the appropriate characteristics selected by the OWNER that shall be the most suitable for the proper protection and coordination of the system at No Additional Cost to the OWNER.

D. Prepare an arc-flash hazard analysis study, and a coordination study, complete with short circuit calculations and coordination curves reflecting calculated fault values and recommended and/or proposed fuse type/ratings, motor protective relay settings, equipment/cable thermal (damage) limits, equipment/device settings (as applicable) from the proposed Austin Energy 12,470V level (with close coordination with Austin Energy upstream devices) through the 208/120V subsystem level equipment and devices. Coordination with Austin Energy is required. Additional details concerning the implementation of the short circuit, coordination, arch flash studies such as main-tie-main circuit breaker states to be assumed, etc., will be provided after Bid Award during the Pre-Submittal conference.

E. In addition to all proposed equipment, the study shall include all existing plant electrical equipment from the proposed Austin Energy 12,470V level (with close coordination with Austin Energy upstream devices) through the 208/120V that is not demolished in this project. The contractor shall coordinate with owner for field data collection of all necessary existing electrical equipment data (e.g., transformer KVA ratings, impedance, etc.), existing cable data, existing protective device settings and protective device data, and other additional data as required for use in the completion of the electrical system studies. The Study shall clearly identify all existing equipment data and existing protective device settings.

F. The study should also include adjustments/ recommendations in the proposed/new protective relaying devices to better coordinate with the existing protective devices in lieu of replacing any of the existing protective devices. Where required, and approved by owner, the study should also include adjustments/recommendations in the existing protective devices to better coordinate with the overall electrical system protective devices. The study shall also include any adjustments, recommendations, and requirements of Austin Energy and be fully coordinated with Austin Energy and Austin Energy's requirements. Coordinate with Austin Energy as required and submit documentation as required to meet Austin Energy's requirements at no additional cost to the Owner. The manufacturer's services should also include setting/re-adjusting and testing/calibration of the proposed protective devices and protective relaying, etc. (Referenced below).

G. The Study shall also include the entirety of the DC power distribution system in the proposed Substation No. 1. At minimum, Arc-Flash, short circuit, and coordination study shall be performed for the entirety of the DC system. All DC system equipment shall be labeled with arc flash labels, as identified in these specifications.

H. Perform the arc flash hazard analysis in conjunction with the short circuit and coordination analysis previously described herein and also in compliance with IEEE 1584 and NFPA 70E standards. The flash protection boundary and incident energy shall be calculated at all points in the distribution system (transformers, motor control centers, panelboards, etc.) where work could be performed on energized parts. The following additional requirements apply for the arc flash hazard analysis:

1. Perform arc flash hazard studies assuming one Austin Energy main utility service is energized, the tie circuit breakers are closed, and the second Austin Energy main utility service is de-energized.

2. Repeat studies for each Austin Energy electrical service.

3. Calculations to address worst case (maximum) hazard analysis. Describe scenario employed in submittals.

I. The arc flash hazard analysis effort shall also include:

1. Reporting incident energy values based upon recommended protective device settings for all equipment,

2. Reporting recommendations to reduce AFIE levels and enhance worker safety

3. Furnish and install label(s) for all equipment included in the study indicating the following, at minimum:

a. System voltage

b. Shock and Flash protection boundaries

c. Personal protective equipment requirements for each electrical task based upon hazard category (including flame resistant clothing requirements).

d. Arc flash incident energy value (cal/cm2)

e. Limited, restricted, and prohibited approach boundaries

f. Study report number and issue date

g. Additional information required by the applicable NFPA and IEEE standards.

h. Labels shall be manufacturer’s standard labels with quantity and mounting location per manufacturer’s standard.

J. THE ARC-FLASH STUDIES, THE SHORT CIRCUIT CALCULATIONS AND ANALYSIS, AND THE COORDINATION STUDY SHALL BE PERFORMED:

1. UTILIZING SKM SOFTWARE, LATEST RELEASE – MICROSOFT WINDOWS VERSION. In addition to the hard copy submittal, an electronic copy of the FINAL VERSION of the short circuit analysis/calculations and the protective device setting curves (time-current curves) and summary setting tables, etc. shall be submitted on CD-ROM.

2. By a State of Texas Registered Professional Engineer. The final version of the studies shall be signed and sealed by a Professional Engineer who is Licensed in the State of Texas as an Electrical Engineer.

K. Manufacturer's technical representative is to set, adjust and test all existing circuit breakers, protective relays, protective devices, etc., in the presence of an Owner representative, where a protective device adjustment is identified in the electrical system studies for the existing protective device and approved by the owner. Additionally, the Manufacturer will select the characteristics of the protective devices that are most suitable for the system in providing

proper protection and coordination. The settings will be based on coordination and short circuit studies performed in compliance with Section 16044 of the Specifications, paragraph 1.09 "Special Manufacturer's Services". Provide the OWNER with test report certified by the manufacturer. Include a record of all settings. Format and quantity of reports shall be per the requirements of Section 01300 and Section 01730 of the Specifications.

L. Any problems encountered with the operation of equipment, parts, components, etc. installed within the new line-up shall be repaired/remedied by the manufacturer's technical representative.

M. The switchgear manufacturer shall provide all necessary services for the rehabilitation of the existing transformers, or employ the services of a transformer rehabilitation specialist, such as Sunbelt Transformer, Ltd., or approved equal, for the rehabilitation of the existing transformers as identified in these specifications and the contract documents. The switchgear manufacturer is to perform all required existing transformer rehabilitation on site and closely coordinate with the Contractor so as to maintain electrical service to the plant for the continued operation of the plant. The rehabilitation effort shall include, but not be limited to, demolition and renovation activity to rehabilitate the existing transformers, site visits to review existing transformers, measurement of existing transformers, and attaining any required documentation from the respective manufacturers of the existing transformers, at no additional cost to the owner.

N. The Switchgear manufacturer shall furnish and install arc-flash labels for all equipment in this study, including existing equipment. The data provided on the arc-flash labels shall be based on arc-flash hazard analysis studies performed by others as well as the arc-flash hazard analysis study described in this Specification, and shall indicate the following, at minimum:

1) System voltage

2) Shock and Flash protection boundaries

3) Personal protective equipment requirements for each electrical task based upon hazard category (including flame resistant clothing requirements).

4) Arc-flash incident energy value (cal/cm2)

5) Limited, restricted, and prohibited approach boundaries

6) Study report number and issue date

7) Additional information required by the applicable NFPA and IEEE standards.

8) Labels shall be manufacturer's standard labels with quantity and mounting location per manufacturer's standard

O. Modifications to Existing 15KV Switchgear

1. Furnish all labor, materials, equipment, incidentals, and services required to provide, and make ready for operation, the MODIFICATIONS required to the existing 15KV switchgear labeled on the PLANS as "SUB2-SWGR-1L" and "SUB2-SWGR-1R" and

located in the existing Substation No. 2. Refer to specification section 16045, Modifications To Existing 15KV Metal Clad Switchgear, for additional information.

P. Manufacturer's technical representative is to set, adjust and test the Substation Management Relays to provide the breaker close permissive for the main, tie, and link breakers at Substation No. 1 and Substation No. 2 based on the statuses of the main, tie, and link breakers at Substation No. 1 and Substation No. 2 so as to disallow a conductive path between two or more utility services.

1.10 WARRANTIES

A. The manufacturer shall warrant that the equipment furnished will be fabricated in accordance with the requirements of this specification and the recommendations of the manufacturer. If, within 5 years after acceptance by the Owner and after the final completion date of the project as indicated in the Contract Documents, the equipment of any parts installed, are found defective because of material, workmanship, selection of materials, or design, the manufacturer shall at the manufacturer's expense furnish and install replacement parts of a design, workmanship, and material approved by the Owner. Any repairs or replacement parts furnished under the above stated warranty shall carry warranties of the same terms as set forth above from the date of its repair or replacement. Cost of Travel, lodging, labor and parts required as a result of any Warranty Work shall be covered by the warranty (the Manufacturer).

PART 2 - PRODUCTS

2.01 GENERAL AND STRUCTURE REQUIREMENTS

A. General

1. Each vertical section shall house no more than one (1) draw-out circuit breaker which shall be located in the bottom front-compartment (bottom-front-bay) of each vertical section. The top front-compartment (top-front-bay) of each vertical section shall house the metering equipment, protective relaying, control power, breaker control interlock wiring, pilot devices (indicating lights, switches, etc.), terminal blocks, terminal strips, control circuitry circuit breakers and fuse blocks, etc. A back-panel shall be furnished and installed in the top-front-compartment of each vertical section of each Switchgear for mounting control devices, instruments, Auxiliary Equipment Ground Bus, Terminal Strips, Terminal Blocks, wireways, etc. i.e. DO NOT MOUNT devices directly to the sheet-metal housings/barriers and/or doors (other than front-visible face mounted metering and pilot devices as well as power protective relaying devices) of the Switchgears. The backpanels shall be painted WHITE (or manufacturer's standard color) and shall hereinafter be named as device panels.

2. Furnish the Metal-Clad Switchgears complete with all necessary equipment, wiring, power, controls, protective relaying, current transformers, potential transformers, space heaters, ground buses, etc. within the compartments as specified herein and as required by the PLANS

3. The stationary primary contacts shall be tin-plated copper and recessed within insulating tubes. A steel shutter shall automatically cover the stationary primary disconnecting contacts when the breaker is in the disconnected position or out of the cell. Provide rails to allow withdrawal of each medium voltage circuit breaker for inspection and maintenance without the use of a separate lifting device.

4. In each vertical section containing a circuit breaker, the front instrument and control compartment (upper compartment) of each breaker Section within each Switchgear shall be completely barriered and isolated from the corresponding circuit breaker compartment (lower compartment) by a solid metal barrier that shall extend the full depth and width of the vertical section.

5. For rigidity during fault conditions all connections to roll-out potential transformer trays and control power transformer trays shall be rigid bus bars insulated to full voltage rating of the Metal-Clad Switchgear assembly.

6. Energized bare parts mounted on doors shall be guarded where the door must be opened for maintenance of equipment or removal of drawout equipment.

7. Each structure shall be shipped with crane lifting provisions and with a maximum width such that they will pass through an opening measuring 6'-0" wide x 8'-0" high, for handling and installation purposes. The split sections of the Metal-Clad Switchgears shall then be bolted and wired together in the field to obtain the assembled Metal-Clad Switchgear line-up. The manufacturer is responsible for providing the experienced non-sales type technical representative to oversee, perform and direct the installation as also required by paragraph 1.09, above.

8. The overall dimensions of each Switchgear line-up shall be as shown on the PLANS. Equipment arrangement within each Switchgear line-up shall also be as shown on the PLANS.

9. An inter-phase barrier shall be self-contained in the circuit breaker compartment and the compartment shall be equipped with an interlock that prevents insertion of the breaker elements if the inter-phase barrier is not in place. The stationary primary contacts shall be tin-plated copper and recessed within insulating tubes.

10. In general, the stationary structure shall be so constructed and arranged that circuit breakers, busses, instrument transformers and controls are completely isolated from each other within the same cubicle and that cubicles are isolated from adjoining cubicles. Power circuits will enter the Switchgear as shown on the PLANS.

11. The 15kV Metal-Clad Switchgears shall be indoor, NEMA-1A gasketed, non-walk-in type, and shall consist of individual vertical sections housing various combinations of circuit breakers and auxiliaries, bolted to form a Metal-Clad Switchgear assembly. Metal side sheets shall provide grounded barriers between adjacent structures and solid removable metal barriers shall isolate the major primary sections of each circuit.

12. Each vertical section of the 15kV Switchgears shall have two (2) flanged and hinged (piano hinge) rear doors which <u>SHALL NOT BE PAD LOCKABLE</u> but <u>shall be BOLTED</u> with HEX-TYPE 316-Stainless Steel Bolts. Additionally, each vertical section of the 15kV Switchgears shall have two(2) flanged and hinged (piano hinge) front doors

and shall be equipped with two(2) 3-point latch type pad-lockable handles. Front and rear doors shall be provided complete with door handles, in addition to providing each door complete with provisions for padlocking. Door handles shall be of 316-Stainless Steel.

13. Comply with the most current requirements of AUSTIN ENERGY relative to primary metering current transformers and potential transformers. The drawings and Specifications depict the most recent model numbers provided by AUSTIN ENERGY for the main incoming line metering transformers. However, the model numbers may change prior to the construction of the 15kV Switchgears. Therefore, coordination with AUSTIN ENERGY IS ESSENTIAL prior to commencing the Shop Drawing Submittal and manufacturing activity of the 15kV Switchgears.

14. The front steel door of the instrument and control compartment (overall upper compartment door) and the front steel door of the breaker compartment (overall lower compartment door) of each vertical section shall be hinged to the main structure, and shall be provided with suitable 3-point latching mechanism which shall be mechanically interlocked with the door handle. Front doors shall also be furnished complete with provisions for padlocking.

15. Vertical section of each 15kV Metal-Clad Switchgear shall contain provisions for conduits entering from below and from top. Also, provide space sufficient to make traditional stress cone terminations.

16. Each structure shall have sufficient ventilation and full access for repair or replacement of any components through the front of the unit only.

17. Each vertical section shall be furnished with a space heater rated for 120 volts A.C. with a dedicated thermostat wired to terminal block in the respective section. Wire the space heater circuitry of each 15kV Switchgear (in conduit) to the 120/208 volt panelboard in the Substation No. 1 Building as shown on the PLANS.

    a. Thermostat:

        1) Type: Heavy Duty line voltage type, suitable for use in controlling heating and cooling circuits. Shall have field adjustable temperature setpoint and also display the measured ambient temperature.

        2) Measurement Range:

            a) Thermostat: 40 to 90 degrees Fahrenheit

            b) Thermometer: 50 to 90 degrees Fahrenheit

        3) Sensing Element: Liquid filled with diaphragm and lever mechanism

        4) Thermometer: Bi-metal type

        5) Number and Type of Output Contacts: One Single Pole Double Throw (SPDT), snap acting

6) Contact Ratings:

a) Heating Contact: 16 ampere at 120 VAC

b) Cooling Contact: 8 ampere at 120 VAC

7) Enclosure: Thermoplastic cover, suitable for vertical or horizontal mounting configuration

8) Accessories:

a) Provide temperature adjustment knob

b) Provide faceplate with each thermostat with temperature measured in degrees Fahrenheit. Faceplate shall include cutout such that the measured ambient temperature is visible.

c) Mount each thermostat in a device enclosure on the enclosure backpanel in accordance with the manufacturer's recommendations.

9) Manufacturer: Johnson Controls Model T26T Series Line Voltage Thermostat, or approved equal.

18. The 15kV Switchgears inclusive of its hinged doors shall be fabricated from not less than 12-gauge steel. All cables and overhead bus duct system must enter/exit the rear compartment of the 15kV Switchgear sections (both top and bottom entry, as shown on the PLANS).

19. Finish: Structure finish shall be primed and painted using the manufacturer's standard finishing process. Finish shall be applied at the manufacturing plant and shall be suitable for indoor located equipment. Color shall be ANSI No. 61 gray.

20. Each door of each switchgear compartment shall be capable of being securely locked by padlock furnished by Owner. Padlock shackle shall be assumed to be ¼" diameter.

2.02 MAIN BUS

A. The main bus shall be tin plated copper and rated as indicated in the PLANS. Bus bars shall have a continuous current rating based on temperature rise in a 40 degrees C ambient. Bus bars will be braced to withstand magnetic stresses developed by currents equal to main power circuit breaker close, carry, and interrupt ratings. The bus shall be insulated and the bus insulation shall be the manufacturer's standard for the Metal-Clad Switchgear's voltage class. The bus supports shall be glass reinforced polyester.

B. The main bus shall extend the entire length of the line-up and shall be rated not less than the ratings shown on the PLANS at the Switchgear's maximum rated voltage. The bus shall consist of rigidly supported insulated tin-plated copper bars, having a symmetrical interrupting duty and a minimum momentary rating as shown on the PLANS. The bus bars shall be of suitable design and cross sectional area to satisfactorily carry the rated current without exceeding the temperature rise as specified in the IEEE and NEMA standards.

C. The main bus shall have insulated tin-plated-copper bars. The Switchgear shall be constructed so that all buses, bus supports and connections shall withstand stresses that would be produced by currents equal to the momentary ratings of the circuit breakers. The main bus shall have provisions for future extension. All bus joints shall be plated, bolted and insulated with easily installed boots. The temperature rise of the bus and connections shall be in accordance with ANSI standards and documented by design tests.

D. The bus insulation shall be of the manufacturer's offered PREMIUM QUALITY heat shrinkable bus insulation (manufacturer's offered premium option for bus insulation at no additional charge to the Owner), at a minimum. Heat shrink all bus insulation.

E. Connections to the bus shall be made with suitable bolts with lock washers, and the copper bars shall be tin-plated at current carrying connections. Use molded removable covers or similar devices at connections to the bus (including incoming and outgoing feeder connections to the 5kV and 15kV Metal-Clad Switchgear buses and overhead bus duct connections to the 15kV Switchgear buses).

F. Bus stand-off insulators shall be High Strength and High Creep finned type high resistant Epoxy insulators. Additionally, utilize high strength and high resistant Epoxy inserts in the bus support barriers and stand-off insulators on switches and fuse mountings.

2.03 GROUND BUSES

A. Main Ground Bus:

1. The main ground bus shall be of high conductivity tin-plated copper with a continuous rating of at least 50 percent of the Metal-Clad Switchgear's main bus rating and shall extend the entire length of each of the Metal-Clad Switchgears.

2. Each ground bus shall be securely attached to the stationary structure so it is accessible from the front of the Metal-Clad Switchgears. All equipment shall be grounded by connection to the ground bus.

3. The main ground bus shall be bolted to each stationary structure and all equipment grounded by direct electrical connection to this bus. Provide for attachment of four (4) 250 kCMIL stranded copper conductors at each end of the ground bus. Additionally, provide terminals on the ground bus for termination of the load circuit ground wires. Quantity and size of terminals shall be as required by the PLANS.

B. Auxiliary Systems Equipment Ground Bus:

1. A high conductivity copper ground bus mounted in the upper-front-compartment of each vertical section of the Metal-Clad Switchgear shall have a minimum length of 12-inches and shall be mounted using a minimum of two (2) 600 volts A.C. stand-off isolators/insulators. The auxiliary systems equipment ground bus shall have a minimum continuous current rating of 200 amperes and shall be furnished with a minimum of twelve (12) terminals (ground lugs).

2. In each vertical section of the Metal-Clad Switchgear, furnish a #1/0 AWG, 600 volts, GREEN insulated, type XHHW-2 grounding conductor to provide a dedicated grounding

bond between each auxiliary systems equipment ground bus and the main ground bus of the respective Metal-Clad Switchgear.

3. In each vertical section of the Metal-Clad Switchgear, extend dedicated equipment grounding conductors from the auxiliary systems equipment ground bus to each instrument and control device installed in the respective vertical section of the Metal-Clad Switchgear.

   a. Each equipment grounding conductor shall not be less than #12 AWG, 600 volts, GREEN insulated, type XHHW-2 grounding conductor.

   b. Do not connect/terminate more than one (1) equipment grounding conductor to a single terminal point on the ground bus. Additionally, DO NOT daisy-chain equipment grounding conductors from one instrument/device to another. Moreover, DO NOT connect/bond equipment grounding conductors of each instrument/device to the Metal-Clad Switchgear enclosure.

2.04 CIRCUIT BREAKER SECTIONS – DRAWOUT VACUUM CIRCUIT BREAKERS

A. Main and Tie Circuit Breakers - Rating:

1. The Switchgears described in this specification shall be designed for operation on a 15kV, three-phase, 3-wire, solidly grounded, 60-hertz system.

2. Each main and tie circuit breaker shall have the following ratings:

Main and Tie Circuit Breaker Rating	**15kV Switchgears**
Maximum Voltage:	15kV
BIL Rated:	95kV
Continuous Current:	2000 Amperes
Rated Short-Circuit Current:	37kA
Three (3) Second Short Circuit Current at Rated Maximum kV:	48kA
Closing and Latching Capability At Rated Maximum kV:	130kA Peak
Nominal 3-Phase MVA Class:	Minimum 1000MVA
Rated Interrupting Time:	Five cycles

B. Feeder/Branch Circuit Breakers - Rating:

1. The Switchgears described in this specification shall be designed for operation on either a 5kV or a 15kV, three-phase, 3-wire, solidly grounded, 60-hertz system.

2. Each feeder/branch circuit breaker shall have the following ratings:

Feeder/Branch Circuit Breaker Rating	**5kV Switchgears**	**15kV Switchgears**
Maximum Voltage:	5kV	15kV
BIL Rated:	60kV	95kV
Continuous Current:	1200 Amperes	1200 Amperes
Rated Short-Circuit Current:	29kA	37kA
Three (3) Second Short Circuit Current at Rated Maximum kV:	36kA	48kA
Closing and Latching Capability At Rated Maximum kV:	97kA Peak	130kA Peak
Nominal 3-Phase MVA Class:	250MVA	Minimum 1000MVA
Rated Interrupting Time:	Five Cycles	Five cycles

C. Circuit Breaker Assemblies (main, tie and feeder/branch circuit breakers):

1. The circuit breakers shall be horizontal drawout type, capable of being withdrawn without a lifting device and/or transport truck. The breakers shall be operated by a motor-charged stored energy spring mechanism, charged normally by a universal electric motor and in an emergency by a manual handle. The primary disconnecting contacts shall be tin-plated copper.

2. Each circuit breaker shall contain three vacuum interrupters separately mounted in a self-contained, self-aligning pole unit which can be removed easily. The vacuum interrupter pole unit shall be mounted on porcelain or glass polyester supports. A contact wear gap indicator for each vacuum interrupter, which requires no tools to indicate available contact life, shall be easily visible when the breaker is removed from its compartment.

3. The secondary contacts shall be tin-plated and shall automatically engage in the breaker operating position, which can be manually engaged in the breaker test position.

4. Interlocks shall be provided to prevent closing of a breaker between operating and test positions, to trip breakers upon insertion or removal from housing and to discharge stored energy mechanisms upon insertion or removal from the housing. The breaker shall be secured positively in the housing between and including the operating and test positions.

5. The vacuum circuit breakers shall be electrically operated. The control voltage shall be provided as shown on the PLANS. Where shown on the PLANS, circuit breakers shall

also be provided with manufacturer's standard heavy duty stored energy capacitive trip accessory device to facilitate circuit breaker trip after loss of control power.

a. 5kV Switchgear: 120 volts AC close, and 120 volts AC Trip.

b. 15kV Switchgear: 130 volts DC close, and 130 volts DC Trip.

6. Each breaker shall be furnished complete with control switches/control stations, pilot devices, etc. as shown on the PLANS.

7. All circuit breaker units of the same rating shall be interchangeable.

8. As minimum, Each Circuit Breaker assembly shall be furnished with the number of NORMALLY OPEN (N.O.) and NORMALLY CLOSED (N.C.) circuit breaker auxiliary contacts shown on the PLANS. However, furnish one (1) additional spare NORMALLY OPEN (N.O.) and one (1) additional NORMALLY CLOSED (N.C.) breaker auxiliary contacts assembly over the number of contacts (of each type), including spare contacts, shown on the PLANS. The required pair of spare contacts applies to each type of breaker action auxiliary contacts (i.e., truck operated, mechanism operated, etc., as depicted on the PLANS). Pre-wired spare contacts shown on the PLANS and/or any additional spare contacts required herein shall be prewired to the appropriate terminal blocks/strips located in the Upper-Front-Compartments (upper front bay/cell) of the associated vertical section of the Switchgears. All mechanism operated circuit breaker auxiliary contacts shall reflect true circuit breaker open and close status positions and shall operate both when the circuit breaker is racked in as well as when the circuit breaker is racked out in the test position. All mechanism operated circuit breaker auxiliary contacts shall reflect circuit breaker open status when the circuit breaker is racked out AND NOT in test position.

2.05 CONNECTION AND TERMINALS

A. All current-carrying connections to the main buses shall be insulated, tin-plated copper, of suitable capacity and to conform to the requirements of the main bus insofar as bracing, temperature limits, etc., are concerned.

B. Connections to the current transformers shall be such that the transformers may be removed and changed without damage to the connections. Utilize shorting terminal blocks/strips for all connections to current transformers. Also refer to Subsection 2.12 and 2.13 of this Section of the Specifications.

C. Provide clamp type terminals for all power and ground cables and stress-cone type termination of all medium voltage power cables.

D. Except for interconnections between sections in each line-up, 5kV Metal-Clad Switchgears shall be designed for bottom and side/end wall entry of wiring for external connections to equipment (side/end wall and bottom conduit and wiring entrance to both 5kV Metal-Clad Switchgears as shown on the PLANS).

E. Except for interconnections between sections in each line-up, 15kV Metal-Clad Switchgears shall be designed for bottom and top entry of wiring for external connections to equipment

(top/bottom conduit and wiring entrance to both 15kV Metal-Clad Switchgears as shown on the PLANS, and top overhead 15kV bus duct entrance to both 15kV Switchgears as shown on the PLANS).

F. All interior wiring to be neatly and carefully installed in suitable wiring gutters, as required. All wiring to be terminated at suitable terminal strips, marked in accordance to the manufacturer's wiring diagram and the wiring diagrams shown on the PLANS. Also refer to Subsection 2.12 and 2.13 of this Section of the Specifications.

G. In addition to the specified spare terminals and spare contact terminals, provide terminals marked for control circuit connections for all devices separate from the breakers.

H. All instrument and control wiring must be tagged at point of termination (at each end). Use heat shrink wire markers. All tags must be typed. Use of handwritten tags will not be permitted. Heat shrink all tags. Also refer to Subsection 2.12 and 2.13 of this Section of the Specifications.

I. Potential transformer leads shall be flexible cable insulated for service at the maximum voltage rating of the Metal-Clad Switchgear.

J. Provide sufficient clearances for all control and small wiring. Secure wiring to hinged doors and panels to the enclosure with flexibility provided around hinges to prevent fatigue and eventual breaking.

K. GROUND STUDS: Furnish and install Grounding Ball Studs, one for each phase terminal, plus one grounded Grounding Ball Stud per each compartment to provide a convenient means of grounding with jumpers.

1. Ground stud shall be tin coated copper, with stainless steel hardware. Ground stud shall have insulated covering to cover ground stud when not in use. The ground stud shall be designed and installed to meet the switchgear dielectric rating even when any grounding stud cover on any ground stud is removed. The ground stud assembly, with insulated cover, shall be UL listed for use in the switchgear or meet installation and testing requirements of IEEE ANSI C37. The ground stud short circuit rating shall at minimum be equal to or greater than the short circuit rating of the switchgear.

2. Furnish and install Ground Studs in the rear compartment of each switchgear section with proposed or future vacuum circuit breaker. At minimum, furnish and install ground studs on the load side of each breaker as well as the utility section for the incoming utility feeder cables. Furnish and install bussing, as necessary, for each phase as well as ground to facilitate installation of the ground studs and to make ground studs safely and conveniently accessible to the Owner.

2.06 UTILITY METERING TRANSFORMERS – 15KV SWITCHGEARS

A. General: All instrument transformers specified shall be installed and connected at the factory. Mount instrument potential transformers in their drawout supports for factory test. Note: The instrument transformers product specifications described herein applies to the following

1. Austin Energy Incoming Line Main Utility Metering Transformers located in the Main Utility Metering dedicated sections of the 15kV Metal-Clad Switchgears lineup.

2. the OWNER's Main Metering Transformers which shall each be installed in sections of the 15kV Metal-Clad Switchgears lineup, separate from the Austin Energy Incoming Utility Metering dedicated sections.

B. Main Utility Metering Instrument current transformers (C.T.'s):

1. Where shown on the PLANS, furnish and install a set of three (3) 1000/2000:5 (dual ratio) BAR TYPE current transformers for the AUSTIN ENERGY incoming line Main Utility Metering section of each 15kV Switchgear, and an additional set of three (3) 1000/2000:5 (dual ratio) BAR TYPE current transformers for the OWNER's Main Utility Metering section of each 15kV Switchgear. All Main Utility Metering current transformers shall be indoor type, 15KV rated, with 0.3% metering accuracy, and a rating factor of 2.00/1.50 at (55°C) and shall be manufactured by ABB Catalog No. 7524A38G08, type KOT-11.

2. Install a tap changing-shorting terminal block for each current transformer (C.T.). Prewire all terminal of each C.T. and dual-ratio C.T. to its respective tap changing shorting terminal block. Shorting terminal blocks shall be as manufactured by "G.E.", or approved equal. Mount shorting terminal blocks (STB's) inside the upper-front compartment of the applicable vertical section of the 15kV Metal-Clad Switchgear. All wiring shall be #10 AWG copper terminated with insulated ring type compression terminators and shall conform to the AUSTIN ENERGY standard color code.

3. Contractor shall coordinate with Austin Energy regarding all utility metering requirements prior to procuring the proposed switchgear. In particular, the Contractor shall attain in writing from Austin Energy approval for the proposed utility metering CT and PT prior to manufacture and shipment of the switchgear. Should the contractor fail to coordinate with Austin Energy regarding the Austin Energy metering requirements prior to the procurement and installation of the switchgear, the contractor shall provide all labor and material to modify the utility metering, as required, to the satisfaction of Austin Energy at no additional cost to the owner.

C. Instrument Potential Transformers (P.T.'s):

1. Where shown on the PLANS, furnish and install a set of three (3) – 12.5kV-to-120Volts AC fused Potential Transformers for the AUSTIN ENERGY incoming line Main Utility Metering section of each 15kV Switchgear, and an additional set of three (3) – 12.5kV-to-120Volts AC fused Potential Transformers for the OWNER'S Main Utility Metering section of each 15kV Switchgear. All Main Utility Metering Potential Transformers shall have 60:1 ratio, 110 kV BIL, 0.3% meter accuracy, and shall be manufactured by ABB Catalog No. 75-25A67G05.

2. Potential Transformers shall be wired to separate potential terminal blocks. Mount potential terminal blocks inside the upper-front compartment of the applicable vertical section of the 15kV Metal-Clad Switchgear. All wiring shall be #10 AWG copper terminated with insulated ring type compression terminators and shall conform to the AUSTIN ENERGY standard color code.

3. The instrument Potential Transformers shall be installed in a draw-out assembly inside the designated section/compartment within the 15kV Switchgears. The instrument Potential Transformers shall also fit into the complete 15kV Metal-Clad Switchgear sections (of both 15kV Metal-Clad Switchgears).

2.07 INSTRUMENT TRANSFORMERS

A. General:

1. All instrument transformers specified shall be installed and connected at the factory. Mount instrument Potential Transformers (P.T.'s) in their drawout supports for factory test. Note: The instrument transformers (C.T.'s and P.T's) product specifications described herein does not apply to the Austin Energy Incoming Line Main Utility Metering Transformers and the OWNER's Main Utility Metering Transformers.

B. Instrument current transformers (C.T.'s):

1. The instrument current transformers (C.T.'s) shall be especially designed for installation in totally enclosed Metal-Clad Switchgears. The design shall coordinate the thermal, mechanical, and insulation limits of the current transformers with that of the vacuum circuit breakers and main bus of the Metal-Clad Switchgear in which they are to be installed.

2. Instrument current transformers shall be of the wound, through or bar and/or window type, with silver-plated primary terminals and suitable insulation over these terminals to withstand ANSI standard test voltages equivalent to the maximum voltage rating of the Switchgear.

3. Provide multi-ratio current transformers. Multi-ratio current transformers shall be of the five (5) terminal type as specified in this section and shown on the PLANS.

4. The accuracy of the instrument current transformers shall be suitable for the meters and/or relays specified, with normal burdens of the various devices of not less than an ANSI standard accuracy classification of 0.3 with burden B-0.1, B-0.5, and B-2.0.

5. Install a tap changing-shorting terminal block for each current transformer (C.T.). Prewire all terminal of each C.T. and multi-ratio C.T. to its respective tap changing shorting terminal block. Shorting terminal blocks shall be as manufactured by "G.E.", or approved equal. Mount shorting terminal blocks (STB's) inside the upper-front compartment of the applicable vertical section of the Metal-Clad Switchgear.

6. Additional requirements for zero sequence (core balance) current transformers:

a. Furnish and install window type zero sequence current transformers. Minimum window opening shall be 20 inches long by 8 inches wide. Window opening size shall be increased as required such to allow mutiple feeder circuit cables to simultaneously pass through the window opening. Current transforrmer shall be located such to allow mutiple feeder circuit cables to simultaneously pass through the window opening. Zero sequence current transformer shall be as manufactured by ABB BYZ-L or approved equal.

C. Instrument Potential Transformers (P.T.'s):

1. The instrument potential transformers and their associated primary and secondary fuses shall be installed in a draw-out assembly inside the designated section/compartment within the Switchgears. The instrument potential transformers shall also fit into and coordinate with the complete Metal-Clad Switchgear sections (of each Metal-Clad Switchgear), and with the instruments, relays, meters and other devices specified.

2. The instrument potential transformers shall have a rating of not less than 150 volt-amp (VA) on an accuracy basis, and 500 volt-amp (VA) on a thermal basis.

3. The instrument potential transformers shall have the following primary and secondary voltage ratings:

a. Primary voltage = 12.5kV for 15kV Switchgears and 4.16kV for 5kV Switchgears

b. Secondary voltage = 120 volt (AC)

c. Frequency = 60 hertz

4. The accuracy classification of the instrument potential transformers shall be 0.3 with burdens of W, X, Y and Z.

5. Install instrument potential transformers with primary and secondary disconnect devices, grounding device, and accessories in conformance with IEEE and NEMA standards. The primary fuses furnished with these transformers shall be of the current limiting type. These fuses must clear a faulted transformer in approximately 1/2 cycle (on 60 cycle basis), but must not blow on magnetizing inrush current nor protect a transformer with a short circuited secondary.

2.08 MICRO-PROCESSOR BASED PROTECTIVE RELAYING AND COMMUNICATION

A. Main and Feeder Circuit Breaker Sections - Metering and Feeder Protective relay "FPR" for Each Metal-Clad Switchgear

1. The main and feeder circuit breaker section of each Metal-Clad Switchgear shall be furnished with Feeder Protective Relay "FPR". Connect each Feeder Protective Relay "FPR" as shown on the PLANS. Each Feeder Protective Relay "FPR" shall be as manufactured by General Electric - MULTILIN model 850. Where the drawings indicate a "Feeder Protective Relay" device, furnish and install the "FPR" as identified in this section of the specifications. In addition, the protective relay is to have the following features as provided by Manufacturer:

a. Phase Current Inputs (refer to PLANS),

b. Ground Current Inputs (refer to PLANS), as well as sensitive ground CT inputs option,

c. 2 Form A and 3 Form C Output Contacts rated minimum 120VAC, 10A continuous, 2A inductive, as well as 7 Discrete inputs (120VAC). These output contacts shall be in addition to the standard Trip and related output contacts.

d. 7 Analog Outputs (4-20mA) as well as 4 Analog Inputs (4-20mA) plus one(1) RTD input

e. 10 Digital Inputs + 4 Arc Flash Inputs

f. Additional I/O, as required, per control schematics as shown in PLANS,

g. Standard Front Panel (Rugged Key Pad),

h. Current Protection: Advanced Configuration,

i. Voltage Monitoring and Protection: Advanced Voltage Metering & Protection,

j. Control: Advanced Control

k. Monitoring: Advanced Monitoring

l. Communications: Advanced Communication,

m. Communications media: Copper Ethernet, unles shown as fiber on PLANS

n. No Wireless Communication

o. Security: Advanced security, CyberSentry Level 1

2. Furnish "FPR" with HI range control power supply option. Control power supply requirements for the Switchgears are: 130 volts DC

B. Medium Voltage Bus AND TRANSFORMER Differential Protective Relay "DPR"

1. Where shown on the PLANS, the 15kV medium voltage overhead tie bus system between the two (2) 15kV Metal-Clad Switchgears shall be protected by a Bus Differential Protective Relay. Connect the Bus Differential Protective Relay as sown on the PLANS. Each Bus Differential Protective Relay shall be as manufactured by General Electric - MULTILIN model 845. Where the drawings indicate a "Bus Protective Relay" device, furnish and install the "DPR" as identified in this section of the specifications. In addition, the protective relay is to have the following features as provided by Manufacturer:

a. Phase Current Inputs 1: (refer to PLANS),

b. Phase Current Inputs 2: (refer to PLANS),

c. Ground Current Inputs (refer to PLANS),

d. 2 Form A and 3 Form C Output Contacts rated minimum 120VAC, 10A continuous, 2A inductive, as well as 7 Discrete inputs (120VAC). These output contacts shall be in addition to the standard Trip and related output contacts.

e. 7 Analog Outputs (4-20mA) as well as 4 Analog Inputs (4-20mA) plus one(1) RTD input

f. 10 Digital Inputs + 4 Arc Flash Inputs

g. Additional I/O, as required, per control schematics as shown in PLANS,

h. Standard Front Panel (Rugged Key Pad),

i. Current Protection: Advanced Configuration,

j. Voltage Monitoring and Protection: Advanced Protection,

k. Control: Standard Control

l. Monitoring: Advanced Monitoring

m. Communications: Advanced Communication,

n. Communications media: Copper Ethernet, unles shown as fiber on PLANS

o. No Wireless Communication

p. Security: Advanced security, CyberSentry Level 1

C. 15kv Switchgears Bus Tie and Incoming Power – Synchronism Check Relay "SCPR"

1. Where shown on the PLANS, the 15kV class incoming power sources (one source per each 15kV Switchgear) shall be checked for synchronism prior to and/or while allowing a closed transition from one source to another. Source synchronization shall be checked by a Solid State Synchronism Check Relay. The Synchronism Check Protective Relay (SCPR) shall be as manufactured by Basler Electric - Basler Model BE1-25 also shown on the PLANS, No Equal. The relay shall have Option 1 with isolated contact sensing, and Option 3 Power Supply Status Output.

D. Substation Management Relay

1. Furnish each Substation Protection Relay "SMR" as shown on the PLANS. Each Substation Management Relay "SMR" shall be as manufactured by General Electric - MULTILIN model C30. Where the drawings indicate a "Substation Management Relay" device, furnish and install the "SMR" as identified in this section of the specifications. In addition, the relay is to have the following features as provided by Manufacturer:

a. Horizontal Orientation, with graphical display, USB front port, and programmable push buttons.

b. 16 form C output contacts rated minimum 130VDC, 8A continuous, 2A inductive

c. 16 Discrete Input Contacts rated 130VDC

d. Cybersentry Level 1 Option

e. 10/100 Base-Tx Ethernet Communication port

f. Inter-Relay Communication Module: 1310nm Dual Channel LASER.

2. Gear Manufacturer shall furnish the SMR and the DCISS shall install the SMR. Gear manufacturer shall closely and carefully coordinate with DCISS. Refer to section 16080.

E. Patch Panel

1. Where patch panel shown on the PLANS or as required by this specification, furnish and install a dedicated patch panel for termination of the Ethernet data highway (serial communication) cabling for each Protective Relay and Power Monitoring Unit. Patch panels shall be two-port, surface mounted, fully enclosed type, Category 6A, with RJ-45 connectors, as manufactured by "Panduit", Model Mini-Com #CBXJ2IW-A, with "Mini-Com TX6" UTP Coupler Module Model CJ6X88TGIW and blank cover plates, or approved equal. Ethernet patch cords shall be furnished and installed between the patch panel and the respective protective relay/power monitoring unit per the requirements of Section 17600 "Distributed Control System".

2.09 POWER MONITORING UNIT (PMU)

A. Where required by the PLANS, furnish and install a Power Monitoring Unit (PMU).

1. The PMUs shall be as manufactured by General Electric - MULTILIN Model EPM 9700 (Transducer Module) with advanced software option complete with three line LED combination display and keypad Model P40NPLUS, with the Ethernet communication capability, harsh environment UL 746C/94 recognized conformal coating on all printed circuit assemblies and all required interconnect cabling as also shown on the PLANS, No Equal. Units shall be connected as shown on the PLANS.

2. Furnish and install an Ethernet connection to the PMU on the door adjacent to the LED display for accessing PMU settings files.

3. Where shown on the PLANS, furnish and install a patch panel in accordance with the requirements of Sub-Section 2.08 E, this Section of the Specifications.

2.10 INSTRUMENT AND CONTROL WIRING

A. General:

1. All Instrument and Control wire/cables shall be UL recognized/CSA approved.

2. Phase sequencing shall have proper identification.

3. Each single wire and/or cable shall be terminated at a terminal block. Also, refer to Subsection 2.14 of this Section of the Specifications.

4. All instrument transformer wiring, wiring to metering and protective relaying devices (Feeder Management Relays, etc.), wiring to control and pilot devices (selector switches, pushbuttons, pilot lights, etc.), control signal and low voltage power wiring in each vertical section of the Switchgears shall be terminated to appropriate Terminal Blocks and Terminal Strips (group of Terminal Blocks) that shall be housed and located in the upper-front-compartment (front-upper-bay) of the same/respective vertical Section. All Terminal Blocks/Strips shall be located within the upper-front-compartment (front-upper-bay) of the respective vertical Section of the Switchgears.

5. The Switchgears shall be completely assembled and wired at the factory such that installation can be accomplished by connecting field wiring to terminal strips located in the panel.

B. Secondary Signal Wiring to/from Instrument Transformers: Instrument Transformers Secondary Signal Wiring to/from Current Transformers, Ground Current Transformers and Potential Transformers shall be installed inside the Metal-Clad Switchgears in suitable wiring gutters. Where not possible to install in wiring gutters, spiral wrapping, or corrugated protective plastic. tubing, etc., must be used. Signal wiring shall be extra flexible 41-strand, tin-plated, 600 volt insulation, dual rated type XLPE (3173) 125° C, SIS 90° C., SIS wire manufactured by General Cable Company, The Okonite Company, or approved equal. Minimum acceptable size shall be #10 AWG.

C. 130 Volts DC - Discrete Control Wiring System – 15kV Switchgears: 130 Volts DC Discrete Control Signal wiring shall be installed inside the 15kV Metal-Clad Switchgears in suitable wiring gutters. Where not possible to install in wiring gutters, spiral wrapping, or corrugated protective plastic tubing, etc., must be used. 130 volts DC discrete control wiring shall be extra flexible 41-strand, tin-plated, 600 volt insulation, dual rated type XLPE (3173) 125° C, SIS 90° C., SIS wire manufactured by General Cable Company, The Okonite Company, or approved equal. Minimum acceptable size shall be #12 AWG.

D. 120 Volts AC - Discrete Control Wiring System – 5kV and 15kV Switchgears: 120 Volts AC Discrete Control Signal wiring shall be installed inside the Metal-Clad Switchgears in suitable wiring gutters. 120 volts AC discrete control wiring shall be extra flexible 41-strand, tin-plated, 600 volt insulation, dual rated type XLPE (3173) 125° C, SIS 90° C., SIS wire manufactured by General Cable Company, The Okonite Company, or approved equal. Minimum acceptable size shall be #12 AWG.

E. ModBus Digital Data Communication System Wiring: All ModBus Digital Data Communication System Wiring shall be twisted pair, #16 AWG stranded copper conductors with 600 volt PVC insulation over each conductor, a tinned copper drain wire, an overall aluminum mylar shield and an outer PVC jacket. Instrument wiring cables shall be manufactured by Belden, or approved equal. Color of the twisted pair shielded cable jacket shall be ORANGE.

F. Control and instrument wiring routed on inside face (directly behind the face) of access doors of the Switchgears and where not possible to route in wiring gutters, spiral wrapping, or corrugated protective plastic tubing, etc., must be used.

2.11 CONTROL AND PILOT DEVICES

A. Selector Switches:

Provide selector switches with the contact operation type (maintained action, momentary action, etc.) where shown on the PLANS. Switches shall be as manufactured by General Electric "G.E." Type SB1, Electro-Switch, or approved equal.

B. Indicating Pilot Lights:

Indicating lights shall be NEMA Style, full size 30-millimeter (30mm), Transformer Type Light Emitted Diode (LED), NEMA 4/13 oil tight and watertight, full size, push to test type, rated at 120VAC or 130VDC, as applicable (refer to PLANS), with legend plate marked as shown on the PLANS. Lens color shall be as shown on the PLANS. Pilot lights shall be as manufactured by Allen-Bradley Bulletin 800T NEMA Type 4/13, oil tight and water tight, or approved equal. Miniature size pilot lights will not be accepted.

C. Control Relays:

1. General Control Relays (non-protective control logic relays):

General control logic relays, where required, shall be 600 volt AC and/or DC, as applicable). Minimum contact rating shall be 10 amperes continuous at the rated operating voltage and voltage type (AC or DC). Furnish each relay with one additional Normally Open (N.O.) and one additional Normally Closed (N.C.) contacts over the number required by the schematic diagrams. Relays shall be furnished with visual mechanical latch-unlatch indicators. Additionally, coil of each relay shall be furnished with Relay Manufacturer's Transient Suppression Module. Relays shall be Allen Bradley Bulletin 700, or approved equal. So called "International" and IEC rated relays will not be accepted. All relays shall be standard NEMA size.

2. General Control Time Delay Relays (non-protective control logic relays):

Solid state, multi-time, and multi-function type relay. Both timing ranges and timing modes shall be field selectable. Each relay shall be capable of the following timing modes: On Delay, Off Delay, One Shot, Repeat Cycle, and Interval. Minimum relay contact rating shall be 10 amps, continuous, at 120 VAC. Coils shall be 120 VAC. Timing relays shall be Square D Class 9050 model No. JCK70 complete with Type NR61 Socket, or approved equal.

3. Mount control relays inside the upper-front-compartment (upper front bay) of each respective and applicable vertical section of the Switchgears. DO NOT mount relays directly to the sheet metal barriers within the vertical sections of the Switchgear sections. Mount relays on the white-painted backpanel (device panels) located inside the upper front-compartment of each vertical section.

D. Lockout relay:

Provide each circuit breaker with Lockout Relay as also shown on the PLANS. The lockout relay shall be hand reset and wired per the PLANS. Lockout relays shall be as manufactured by Electro-Switch Series 24, General Electric Company "G.E", or approved equal.

2.12 INSTRUMENT AND CONTROL WIRING TERMINAL BLOCKS AND ASSOCIATED WIRING METHOD

A. Terminal Block and/or Terminal Strip:

1. Terminal blocks used 120 volts AC, 130 volts DC and 24 volts DC instrumentation and control wiring shall be NEMA Terminal Blocks, 600 volts with continuous current rating of 30-amperes, nylon or polypropylene, snap together Knife-Style isolating terminal blocks. Terminal blocks shall be mounted on a Heavy Duty DIN Rail. Terminal blocks shall be manufactured by Allen-Bradley catalog No. 1492-WKD6 (33 terminals per foot) complete with 1492-SM6X12 detachable multi-character Snap-in Marker Card, and manufacturer's insulated side jumpers, or approved equal. Use of wire as jumper between terminal blocks will not be accepted. Tag each terminal block (each point on a terminal strip). Tag of each terminal block shall be typed with an indelible marking process. Handwritten tags WILL NOT BE ACCEPTED.

2. Shorting Terminal Blocks for wiring to/from Instrument Current Transformers: Terminal blocks shall be Tap-Changing-Shorting Terminal Blocks, NEMA Terminal Blocks, 600 volts with minimum continuous current rating of 55-amperes. The Shorting Terminal Blocks (designated on the PLANS as STB's) shall be utilized for secondary wiring of all Multi-Ratio and Dual Ratio Current Instrument Transformer. The Shorting Terminal Blocks shall be as manufactured by General Electric "G.E.", or approved equal.

B. Terminal Strip/Block General Wiring Methods, Tagging and Identification:

1. Terminal strips/blocks associated with wiring of equipment within a vertical section of the Switchgears shall be located in the UPPER-FRONT COMPARTMENT (upper front bay) of the respective vertical section (lower front bay or lower compartment shall be utilized for drawout assemblies such as circuit breakers, Potential Transformers P.T.'s, and window type Current Transformers C.T.'s, etc.).

2. Each instrument and control wiring terminal block shall be in a vertical section of the Switchgears shall be mounted on a heavy-duty RAIL (DIN-RAIL mount). Each Terminal Strip within a vertical section shall be mounted on a rail that is physically isolated from any other terminal strip and associated rail in the section. All Terminal Strips must be separated from one another.

3. UNDER NO CIRCUMSTANCES SHALL ANY WIRE RUN FROM ONE DEVICE TO ANOTHER WITHOUT GOING THROUGH AND BEING TERMINATED TO A TERMINAL BLOCK. A point or multiple of points of wiring termination located at any device shall not be considered the same as a terminal point OR termination point on a Terminal Block NOR shall it be considered the same as Terminal Block(s). Also, refer to the requirements shown on the PLANS.

4. Tag each individual Terminal Block. Each terminal shall have the same tag as the tag of the wire connected to the respective terminal. Utilize the Terminal Blocks manufacturer's tagging assembly (markers, marking strip, etc.) as specified in this Section of the Specifications. All tags must be typed and neatly attached to the marking surface per the recommended procedure of the Terminal Block Manufacturer. Handwritten tags WILL NOT BE ACCEPTED.

5. Physically segregate/separate and isolate AC control wiring terminal strips and its associated DIN-RAIL mount from the DC control wiring terminal strips and its associated DIN-RAIL mount. Also, refer to terminal strip layout and arrangement shown on the PLANS.

6. Utilize the terminal block manufacturer's plated copper terminal-to-terminal insulated side jumpers for making connections between adjacent terminal blocks and/or between terminal blocks located on the same terminal strip. Use of wires as jumpers between terminal blocks will not be accepted.

7. DO NOT mount Terminal Strip assemblies (inclusive of DIN Railing, where applicable) directly to the sheet metal barriers within the vertical sections of the Switchgear sections. Mount Terminal Strip assemblies on the white-painted backpanel located inside the upper front-compartment of each vertical section.

2.13 DEVICE/COMPONENT IDENTIFICATION AND WIRE TAGGING REQUIREMENTS

A. Properly identify all devices, general control relays, CT's, PT's, CPT's, PMU's, FMR's, Pilot Lights, Terminal Blocks, terminal strips, shorting terminal blocks, breakers, auxiliary contact blocks...etc. that are located within/inside, on face, and on back (access doors/panels) of each section/compartment of the Metal-Clad Switchgears. For identification nameplates of equipment located inside/within each section of the Metal-Clad Switchgears, utilize manufacturer's standard laminated labels, "Black" with White typed lettering. Secure and attach label per manufacturer's standards. Lettering type and size shall be as such that is clear and visible and acceptable to the Owner.

B. Identify all wiring, such as control/status wiring, power wiring, instrument wiring, etc. at the terminal blocks, lugs, starter/controller/auxiliary compartments, at termination to control devices/PMU's/ FMR's/Instruments/ CT's/PT's,....etc. Each end of a wire shall be tagged with manufacturer's standard heat shrinkable wire tags. All wire tag identifications, etc. must be typed and not handwritten and shall be per manufacture's standards.

C. Provide identification strips for all terminal blocks, marked in compliance with the applicable wiring diagram drawings (as-builts). Handwritten marking on wiring and terminal blocks will not be accepted. All marking/identification of terminal blocks and wiring shall be typed and shall be per the manufacturer's standard.

D. Furnish and install laminated 3-ply "Black-White-Black", phenolic identification nameplate for each equipment/device/etc. installed/mounted on the face of the Metal-Clad Switchgears. Lettering font shall be manufacturer's standard with minimum lettering size of 1/4" in height. Attach nameplate with 316 Stainless Steel screws, use of adhesives shall not be accepted. Note: Each pilot and control device shall be provided with a function and device Name-Tag identification nameplate in addition to the device manufacturer's legend plate

E. Properly identify each section and compartment of the Metal-Clad Switchgears. For identification nameplates, utilize laminated 3-ply phenolic, "Black-White-Black", plastic laminated nameplates, a minimum of 3/32" thick, with white lettering on black background. Lettering font shall be manufacturer's standard. Attach nameplate with 316 Stainless Steel screws.

1. Minimum lettering size of identification nameplates pertaining to section/compartment content and name identification in the Metal-Clad Switchgears shall be 1/2” in height.

2. For each door of each section, furnish and install nameplates clearly identifying the section/compartment content and name identification on front and rear of the switchgear and, for breaker sections, install nameplates on front and rear of the switchgear clearly identifying the section/compartment content, associated breaker tag, and the load served.

F. For devices mounted on the face of the doors of the Metal-Clad Switchgears, install identification nameplate on the back side of the doors in addition to the nameplates installed on the front face of the Metal-Clad Switchgears. Nameplates installed on the back side of the doors shall be per the requirements of paragraph-A (above) of this subsection.

2.14 LIGHTNING AND SURGE ARRESTERS

A. General:

In the incoming line section of each Metal-Clad Switchgear, install three (3-phase) station class lightning arresters, and three (3-phase) station class surge capacitors, as shown on the drawings.

B. Lightning Arresters:

Station class (type), 3-phase lightning arresters with rating equivalent to the maximum voltage rating of the respective Metal-Clad Switchgear. Lightning arresters shall be U.L. listed and certified, and of valve type. Install three lightning arresters in the incoming line section of each Metal-Clad Switchgear, as shown on the drawings.

C. Surge Capacitors:

Station class (type), 3-phase surge capacitors with rating equivalent to the maximum voltage rating of the respective Metal-Clad Switchgear. Surge capacitors shall be U.L. listed and certified, and of sway capacitors. Install three surge capacitors in the incoming line section of each Metal-Clad Switchgear, as shown on the drawings.

2.15 600 VOLT MOLDED CASE CIRCUIT BREAKERS

A. Where required by the PLANS, install 600 volts AC/DC (120/208 volt AC, 480 volts AC, or 130 volts DC, as applicable) molded case circuit breakers in the Metal-Clad Switchgears, as shown on the PLANS.

B. Molded case circuit breakers shall be thermal magnetic molded case circuit breakers with continuous current rating indicated on the PLANS (at the operating voltage of the system). Breakers shall operate continuously, without tripping, when operating/running current is equal to 80% of the long time trip setting (or frame rating, as applicable) of the breakers. Furnish and install current limiting type circuit breakers where called for, and with the characteristics noted, on the PLANS.

C. Circuit breaker shall be one (1), two (2) or three (3) poles (as shown on the PLANS), 600 volts AC or 600 volts DC, with a maximum continuous current carrying capacity shown on the PLANS and a U.L. listed minimum RMS symmetrical short circuit current rating equal to

or greater than the minimum RMS symmetrical short circuit current rating shown on the PLANS (at the operating voltage of the system). However, under no circumstances shall the RMS symmetrical short circuit current rating of the circuit breakers be less than 42,000 amperes at the operating voltage of the system (480 volts AC, 208/120 volts AC, 130 volts DC, etc., as shown on the PLANS). Breakers shall be U.L. listed and shall comply with NEMA Standard No. AB1-1975 and Federal Specification W-C-3758/GEN 21a. Circuit breaker shall be fully rated and not require rating for ambient temperatures of 40 degrees C. or less.

2.16 250/125 VOLTS CLASS "DC" INDUSTRIAL GRADE POWER DISTRIBUTION CENTERS - 15KV METAL-CLAD SWITCHGEARS

A. In each vertical section of each 15kV Metal-Clad Switchgear AND where required by the PLANS, install 130 volts DC Power Distribution Center. The DC power distribution center shall hereinafter be referred to as DC-PDC.

B. Each DC-PDC shall be in compliance with the manufacturer's industrial-grade panelboard assembly including the circuit breaker coverplate but excluding the overall panelboard enclosure. The Power Distribution Centers shall be U.L. listed and approved for installation inside respective 15kV Metal Clad Switchgears.

C. Each DC-PDC shall be equipped with 600 volts tin-plated copper bussing system of the appropriate number of phases and current ratings. However, the minimum continuous current rating of each bus shall be 100 amperes at the required operating voltage(s) of the bussing system. The minimum RMS symmetrical short circuit current rating of the bus shall be as indicated on the PLANS. Otherwise the minimum RMS symmetrical short circuit current rating of the bus shall be 42,000 amperes.

D. The bussing assembly shall be suitable for installation of bolt-on type circuit breakers.

E. Each DC-PDC shall be installed complete with the number of circuit breakers required by the PLANS.

F. Circuit breaker type and interrupting installed in each DC-PDC shall be as follows:

1. Circuit breakers shall be 600 Volts DC, thermal magnetic molded case circuit breakers with continuous current rating indicated on the PLANS (at the operating voltage of the system). Breakers shall operate continuously, without tripping, when operating/running current is equal to 80% of the long time trip setting (or frame rating, as applicable) of the breakers. Furnish and install current limiting type circuit breakers where called for, and with the characteristics noted, on the PLANS.

2. Circuit breaker shall be two (2) poles (as shown on the PLANS), 600 volts DC, with a maximum continuous current carrying capacity shown on the PLANS and a U.L. listed minimum RMS symmetrical short circuit current rating equal to or greater than the minimum RMS symmetrical short circuit current rating shown on the PLANS (at the operating voltage of the system). However, under no circumstances shall the RMS symmetrical short circuit current rating of the circuit breakers be less than 42,000 amperes at the operating voltage of the system (130 volts DC, as shown on the PLANS). Breakers shall be U.L. listed and shall comply with NEMA Standard No. AB1-1975 and

Federal Specification W-C-3758/GEN 21a. Circuit breaker shall be fully rated and not require rating for ambient temperatures of 40 degrees C. or less.

G. Protective covering shall be installed on the unused breaker spaces of the DC-PDC assemblies.

H. The circuit breaker cover of the DC-PDC assemblies shall be finished and painted GRAY ANSI#61.

I. The DC-PDC shall be Power Distribution Class Panelboards (excluding exterior enclosure) as manufactured by Cutler-Hammer Corporation Type 4B (short panel), or approved equal I-Line Distribution Panelboard by Square-D Company, or approved equal by General Electric Company "G.E." Power Distribution Class Panelboard.

J. Mount DC-PDC assemblies to the device-back-panels located inside the front-upper-compartment of each vertical section of each Switchgear. Utilize a minimum of two (2) 600 volt AC/DC isolators/insulators for mounting each DC-PDC.

2.17 MEDIUM VOLTAGE (15KV) OVERHEAD BUS DUCT SYSTEM

A. Rating:

12,470 volt, 2000 amperes, 3-phase, 3-wire, braced to withstand not less than 1000MVA symmetrical interrupting duty and a minimum momentary rating of 80KA at 12,470 volts.

B. Bus bars:

Insulated flat tin-plated copper bar, full round edge, type ETP, 100% conductivity. Of suitable design and cross sectional area to satisfactorily carry rated current without exceeding IEEE and NEMA specified temperature rise. Current carrying capacity based on actual service conditions, including skin and proximity effect, insulation, steel enclosure and ambient temperature of 40 degrees C.

C. Insulation:

The bus insulation shall be of the manufacturer's offered PREMIUM QUALITY insulation (manufacturer's offered premium option for bus insulation at no additional charge to the Owner). High resistance conducting surface in contact with the bus to eliminate corona damage to bus insulation. Heat shrink all bus insulation.

D. Supports:

All bus supports (insulation from ground) shall be High Strength and High Creep finned type high resistant Epoxy insulators.

E. Connections to bus duct:

Suitable bolts and lockwashers. Tin-plated copper bars at all current carrying connections. Provide molded removable covers at connections to the bus. At final connection point of the overhead bus duct to the switchgear assembly, utilize tin-plated extra flexible soft and braided copper connectors which shall meet the same technical

specifications as the main bus bars of the switchgears and the overhead bus duct systems, described in this section of the specification.

F. Housing:

Flange to flange, gasketed dust-tight and water-tight, non-ventilated, corrosion resistant #11 gauge steel enclosure. The enclosure shall have bolted removable housing. The enclosure shall be designed to be hung from overhead by hangers.

G. Space Heaters:

Two 125 watt, 120 volt type minimum, complete with thermostatic control contained within the housing of each bus duct. Wire (in conduit) to the 120/208 volt panelboard in the Substation No. 1 building.

PART 3 - EXECUTION

3.01 15KV METAL-CLAD SWITCHGEARS

A. Level and mount Metal-Clad Switchgears with leveling channels and anchoring bolts, as recommended by the manufacturer and detailed on the drawings. Leveling insert type channels shall be 316 stainless steel, as manufactured by "Unistrut" Series 3783-ST, or approved equal. Install leveling insert channels in the concrete floor slab of the Switchgear building, as detailed on the drawings. All mounting hardware shall be stainless steel.

B. The manufacturer shall provide certified copies of factory test reports prior to shipment of the equipment to the project site. Format and quantity of reports shall be per the requirements of Section 01300 and 01730 of the Contract Specifications.

C. Furnish the services of the manufacturer's technical representative (non-sales type representative) to assist and supervise in the installation of the equipment, and to perform the initial operation (start-up). Also, refer to the requirements of Subsection (paragraph) 1.09 in this section of the specifications.

D. Test the control power transformers "CPT's" in accordance with the provisions of Section 16800 – "Calibration, Testing and Setting". Additionally, megger test (minimum 1000 megohms) primary windings to shield, secondary windings to shield, in addition to primary to ground and secondary to ground.

E. Wire the space heater circuitry of each Metal-Clad Switchgear as shown on the PLANS. Location and quantity of space heater circuits and associated points of terminations shown on the PLANS are approximate estimates, exact and final location of the space heaters as well as the number of circuits and associated points of terminations shall be based on, and as shown on, the manufacturer's shop drawing submittals. Make all field modifications as required by the manufacturer's submittal drawings and as pre-approved/pre-accepted by the Engineer/Owner, and make all final connections to the satisfaction of the Engineer/Owner and at No additional cost to the Owner.

3.02 MEDIUM VOLTAGE (15KV) OVERHEAD BUS DUCT SYSTEM

A. Install in accordance with manufacturer's recommendations and as shown on the PLANS.

B. Provide supports as shown on the PLANS or as otherwise required and recommended by the manufacturer.

C. Connect to the 15kV Switchgears (inside the appropriate vertical sections) with braided flexible connectors.

D. Wire the space heater circuitry of the Overhead Bus Duct (in conduit) to the 120/208 volt panelboard in the Substation No. 1 building. Location and quantity of space heater circuits and associated points of terminations shown on the PLANS are approximate estimates, exact and final location of the space heaters as well as the number of circuits and associated points of terminations shall be based on, and as shown on, the manufacturer's shop drawing submittals. Make all field modifications as required by the manufacturer's submittal drawings and as pre-approved/pre-accepted by the Engineer/Owner, and make all final connections to the satisfaction of the Engineer/Owner and at No additional cost to the Owner.

E. Test for proper phasing of power connections.

F. Standard factory tests shall be performed on the equipment specified under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards. The manufacturer shall provide certified factory test reports prior to shipment of the equipment to the project site. Format and quantity of reports shall be per the requirements of Section 01300 and Section 01730 of the Contract Specifications.

G. Follow manufacturer's instructions and approved practice for installation of the equipment. Refer to Subsection 1.09, this Section of the Specifications.

H. Furnish the services of the manufacturer's technical representative (non-sales type representative) to assist and supervise in the installation of the equipment, and to perform the initial operation (start-up). Include time to correct any defects or malfunctions. The manufacturer shall provide a report certifying that the equipment was installed in accordance with manufacturer's recommendations and are in proper working order. Format and quantity of reports shall be per the requirements of Section 01300 and Section 01730 of the Contract Specifications. Also, refer to Subsection 1.09 in this Section of the Specifications.

3.03 FACTORY TESTING

A. As minimum, the following standard factory tests shall be performed on the circuit breaker element provided under this section. All tests shall be in accordance with the latest version of ANSI standards:

1. Alignment test with master cell to verify all interfaces and interchangeability

2. Circuit breakers operated over the range of minimum to maximum control voltage

3. Factory setting of contact gap

4. One-minute dielectric test per ANSI standards

5. Final inspections and quality checks

B. The following production test shall be performed on each breaker housing:

1. Alignment test with master breaker and/or breaker installed in the accompanying Switchgear to verify interfaces and interchangeability

2. One-minute dielectric test per ANSI standards on primary and secondary circuits

3. Operation of wiring, relays and other devices verified by an operational sequence test.

4. Control circuits algorithm tests, hard-wired auto-transfer logic tests, protective device trip/alarm and breaker lockout/interlock tests.

5. Final inspection and quality check.

C. The manufacturer shall provide copies of the factory test reports per subsection 3.01 (above) of this Section of the Specifications.

D. Factory tests as outlined above shall be witnessed by the Owner's representative. The manufacturer shall include cost of two (2) factory trips, each trip attended by six (6) of the Owner’s representatives.

1. The manufacturer shall notify the owner six (6) weeks prior to the date the tests are to be performed.

2. The manufacturer shall include the cost of transportation and lodging (e.g.-airfare, rental car, hotel rooms, etc.) for up to six (6) Owner's representatives, per factory trip, and for a duration of up to 5-standard business days per factory trip, and 8-standard business hours per standard business day. Standard business days are Monday through Friday, excluding National Holidays. Standard business hours 8:00 a.m. to 5:00 p.m. during standard business days. The cost of meals and incidental expenses during each trip shall be the owner's responsibility.

3.04 FIELD QUALITY CONTROL

A. Furnish the services of the manufacturer’s technical representative (non-sales type representative) to assist and supervise in the installation of the equipment, connections and adjustments, and testing of the Switchgears components contained therein.

B. The manufacturer’s technical representative (non-sales type representative) shall perform the initial operation (start-up). Include time to correct any defects or malfunctions.

C. Refer to the requirements of Subsection (paragraph) 1.09 in this Section of the Specifications.

3.05 FIELD ADJUSTMENTS AND TESTING

A. Set, adjust and test all protective relays based on the results of the coordination study.

B. Refer to the requirements of Subsection (paragraph) 1.09 in this Section of the Specifications.

C. Check phasing across the switchgears and connecting overhead bus duct utilizing phasing sticks.

3.06 MANUFACTURER'S CERTIFICATION

A. The manufacturer shall provide a report certifying in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations and are in proper working order.

B. Format and quantity of Certification Reports shall be per the requirements of Section 01300 and 01730 of the Contract Specifications. Also, refer to Subsection 1.09 in this Section of the Specifications.

3.07 TRAINING

A. Provide training sessions for the Owner's representatives for Five (5) standard business days (normal workdays) at the job-site location and/or at a location determined by the Owner. If training is conducted in less than the time required by these Specifications, the remaining time shall be utilized at the discretion of the Owner.

B. The training session shall be conducted by the same manufacturer's non-sales-type technical representative who performed the field installation assistance and start-up/setting/adjustment services.

C. At minimum, the training session shall include:

1. Operation and maintenance procedure for the equipment and all components contained within the Metal-Clad Switchgears and training associated with the medium voltage overhead bus duct system.

2. Calibration, setting, adjusting and testing the microprocessor based metering and protective relays (units).

3. Use of calibration and setting software associated with the various microprocessor based metering and protective relays (units).

4. Factory contact persons phone numbers, persons names, ordering procedures and procedures to follow to obtain meaningful results from the factory.

3.08 MEASUREMENT AND PAYMENT

A. No separate measurement or payment for work performed under this Section. All costs are included in the Base Bid.

END OF SECTION

SECTION 16045

MODIFICATIONS TO EXISTING 15KV METAL CLAD SWITCHGEAR

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment, and incidentals required to provide, and make ready for operation, the MODIFICATIONS required to the existing 15KV switchgear labeled on the PLANS as "SUB2-SWGR-1L" and "SUB2-SWGR-1R" and located in the existing Substation No. 2, as specified herein and as also noted/shown on the PLANS. The existing 15KV Switchgear in the existing Substation No. 2 is a product of Eaton ("Cuttler Hammer"), G.O. number MUX00815.

B. The existing Switchgear are vital to the South Austin Regional Wastewater Treatment Plant process. Therefore, required interruptions to the plant process shall be minimized and carefully coordinated with the Owner.

C. The arrangement and dimensions of the existing switchgear are based on the data available and information provided by the Owner and based on site investigations. The Contractor shall also field verify all available data/information prior to commencement of the improvements required under this project.

1.02 RELATED WORK NOT INCLUDED

A. PLANS designated type, number, size and rating of devices included in the Switchgear.

1.03 QUALIFICATIONS

A. All parts and distribution and control equipment required to modify the existing Switchgear at the existing Substation No. 2 shall be the product of the original manufacturer of the switchgear, NO EQUAL, for use in the existing Switchgear, and as also called for on the PLANS and in compliance with this Section of the Specifications. Substitute manufacturers will not be accepted.

B. Modifications to the Switchgear shall be performed and tested in accordance with the latest applicable requirements of NEMA, ANSI, UL, and NEC standards. Modifications to the Switchgear shall maintain the UL listing of the existing Switchgear. Modifications to the Switchgear shall be performed by qualified, experienced, manufacturer trained technical (non-sales type) representative, or Engineering Services Group trained technical (non-sales type) representative, or Original Equipment Manufacturer's trained technical (non-sales type) representative, by Eaton Corporation, Allen Bradley, Square-D Company, Asian Brown Boveri, General Electric Corporation "G.E, or approved equal.

C. In addition to these Specifications, refer to the PLANS for specific requirements on the Switchgear.

1.04 SUBMITTALS

A. Submit shop drawings in accordance with the requirements of Section 01300 of the Specifications. For each individual Switchgear, include internal component/device layouts, dimensions, wiring diagrams, component listings by manufacturer, catalog numbers, spare parts list, equipment data sheets and catalog cut sheets of all equipment and components needed for renovation installed within the SWITCHGEAR complete with part numbers, the nameplate schedules including all internal components, and overall individual equipment control schematics. Modification wiring diagrams for each modified breaker cell shall be inclusive of both all the existing logic wiring and components as well as the added/renovated logic and components such that the final wiring diagram deliverable is a complete diagram representing the wiring, in its entirety, for each modified breaker cell. Submit protective device coordination curves and current limiting circuit breaker/fuse peak current let through curves, where applicable.

1.05 OPERATION AND MAINTENANCE MANUALS

A. Furnish Operation and Maintenance Manuals in accordance with the requirements of Section 01730 of the Specifications. Include at minimum the following for all the added/renovated components:

1. Installation and operation manual.
2. Renewal parts bulletin.
3. Component description, rating, catalog number etc.
4. Vendor drawings.
5. As built drawings, including certified and approved shop drawings.
6. Test data.
7. Full equipment nameplate information in accordance with the latest edition of NEMA.

1.06 DELIVERY STORAGE AND HANDLING

A. Deliver, store, protect, and handle products in conformance with manufacturer's recommended practices as outlined in applicable Installation and Maintenance Manuals.

B. Inspect and report concealed damage to carrier within their required time period.

C. At all times, store products in a clean and dry space. Maintain factory protection and/or provide an additional non-porous extra heavy duty plastic weatherproof housing. Cover to protect products from dirt, water, construction debris, and traffic.

D. Handle in accordance with NEMA and manufacturer's written instructions. Lift only by lifting means provided for this express purpose. Handle carefully to avoid damage to product internal components, enclosure, and finish.

E. Any problems encountered with the operation of equipment, parts, components, etc. installed within the SWITCHGEAR line-up shall be repaired/remedied by the manufacturer's technical representative at no additional cost to the Owner.

F. Do not store equipment in direct contact with the ground.

1.07 TOOLS AND SPARE PARTS

A. Furnish the following spare parts with the equipment for each SWITCHGEAR in conformance with the specifications

1. One set (minimum 3) of fuses for each type and size used.

2. One spare control relay for each type used. Control relay shall be furnished complete with relay coils, Four (4) Normally Open (N.O.) contacts, Four (4) Normally Closed (N.C.) contacts, and shall be furnished with Relay Manufacturer's Transient Voltage Suppression Module.

3. 25 percent spare push-buttons, selector switches, indication light assemblies for each type used (minimum of 2 per type).

4. 50 percent of spare lenses and lamps for each type and color size and type used (minimum of 4 per type).

1.08 SPECIAL MANUFACTURER'S SERVICES

A. Furnish the services of a qualified, experienced, factory trained technical (non-sales type) representative to perform the modifications to the Switchgear. Include checking alignment of parts, wiring connections, operation of all parts (circuit breakers, relays, monitoring relays, etc.). Include time to correct and recheck any discrepancies which are discovered. Also include a report certifying that the equipment was installed properly tested and set in accordance with the Specifications and is in satisfactory operating condition. This certified report shall be provided to the Owner. Format and quantity of reports shall be per the requirements of Section 01300 of the Specifications.

B. Manufacturer's technical representative is to set, adjust and test all circuit breakers, relays, monitoring devices/units, etc. in the presence of a representative of the City of Austin Water Utility for all devices renovated in this project. A list of the protective device settings associated with the circuit breakers modified in this project will be furnished by the City of Austin Water Utility. Coordinate with Owner to collect such data. Additionally, the Owner will provide the Manufacturer with the characteristics of the protective devices that are most suitable for the system in providing proper protection and coordination. The selection will be based on the manufacturer's submittal of a variety of protective device curves for the Owner to select from. The settings will be based on coordination and short circuit studies performed by the Switchgear manufacturer, refer too specification section 16044. Provide

the Owner with a test report certified by the manufacturer. Include a record of all settings in the test report. Format and quantity of reports shall be per the requirements of Section 01300 of the Specifications. The Manufacturer shall furnish the protective device of the appropriate characteristics selected by the Owner that shall be the most suitable for the proper protection and coordination of the system at No Additional Cost to the Owner.

C. For existing switchgear cubicles with new breakers and existing switchgear Main and Tie breakers, Manufacturer's technical representative shall test the entirety of the breaker control logic, including the existing hardwired logic, all control logic modifications (if any), as well as all signals (existing and proposed) telemetered to/from the Owner's SCADA system, to assure a fully functional breaker assembly.

D. Manufacturer's technical representative is to test, troubleshoot, correct, then re-test any modifications (e.g. breaker additions, control logic modifications, CT settings modifications, relay setting modifications, etc.) for devices/units, etc. in the presence of a representative of the City of Austin Water Utility for all devices in the switchgear renovated/modified in this project.

E. Any problems encountered with the operation of equipment, parts, components, etc. installed within the Switchgear line-up shall be repaired/remedied by the manufacturer's technical representative at no additional cost to the Owner.

PART 2 - PRODUCTS

2.01 GENERAL

A. For additional construction notes and special requirements, refer to the PLANS.

B. All parts and distribution equipment shall be the original parts of the original manufacturer of the respective SWITCHGEARs and as recommended/approved by the original manufacturer of the individual existing SWITCHGEARs for use in the existing and respective SWITCHGEARs, and as also called for on the PLANS (where applicable).

C. Any modifications required to the structure of the SWITCHGEARs including the doors, etc., shall be executed by the manufacturer's non-sales type technical representative.

2.02 CONSTRUCTION

A. The requirements described herein and as shown on the PLANS apply to any modification work to the SWITCHGEARs including the relocating and/or modification of existing circuit breaker, etc.

B. Switchgear SHALL NOT EXCEED the dimensions shown on the PLANS. Compartment/component arrangement shall be as shown on the elevation drawings shown on the PLANS. Provide for outgoing circuits exiting from above and below.

C. Wiring

1. 130 Volts DC - Discrete Control Wiring System – 15kV Switchgears: 130 Volts DC Discrete Control Signal wiring shall be installed inside the 15kV Metal-Clad Switchgears in suitable wiring gutters. Where not possible to install in wiring gutters, spiral wrapping, or corrugated protective plastic tubing, etc., must be used. 130 volts DC discrete control wiring shall be extra flexible 41-strand, tin-plated, 600 volt insulation, dual rated type XLPE (3173) 125° C, SIS 90° C., SIS wire manufactured by General Cable Company, The Okonite Company, or approved equal. Minimum acceptable size shall be #12 AWG.

2. 120 Volts AC - Discrete Control Wiring System – 5kV and 15kV Switchgears: 120 Volts AC Discrete Control Signal wiring shall be installed inside the Metal-Clad Switchgears in suitable wiring gutters. 120 volts AC discrete control wiring shall be extra flexible 41-strand, tin-plated, 600 volt insulation, dual rated type XLPE (3173) 125° C, SIS 90° C., SIS wire manufactured by General Cable Company, The Okonite Company, or approved equal. Minimum acceptable size shall be #12 AWG.All Control wiring shall be SIS stranded copper wiring not smaller than #12.

3. All wiring shall be neatly bound with tie-wraps and supported to wire way supports.

4. One spare Normally Open (N.O.) and one Normally Closed (N.C.) contact on all relays, selector switches, push buttons, “M” contact, alarm points, etc. shall be wired to terminal blocks.

2.03 MISCELLANEOUS ACCESSORIES

A. Selector Switches:

1. Provide selector switches with the contact operation type (maintained action, momentary action, etc.) where shown on the PLANS. Switches shall be as manufactured by General Electric “G.E.” Type SB1, Electro-Switch, or approved equal.

B. Indicating Pilot Lights:

1. Indicating lights shall be NEMA Style, full size 30-millimeter (30mm), Transformer Type Light Emitted Diode (LED), NEMA 4/13 oil tight and watertight, full size, push to test type, rated at 120VAC, with legend plate marked as shown on the PLANS. Lens color shall be as shown on the PLANS. Pilot lights shall be as manufactured by Allen-Bradley Bulletin 800T NEMA Type 4/13, oil tight and water tight, or approved equal. Miniature size pilot lights will not be accepted.

C. Control Relays:

1. General Control Relays (non-protective control logic relays):

a. General control logic relays, where required, shall be 600 volt AC and/or DC, as applicable). Minimum contact rating shall be 10 amperes continuous at the rated operating voltage and voltage type (AC or DC). Furnish each relay with one additional Normally Open (N.O.) and one additional Normally Closed (N.C.) contacts over the number required by the schematic diagrams. Relays shall be furnished with visual mechanical latch-unlatch indicators. Additionally, coil of each

relay shall be furnished with Relay Manufacturer's Transient Suppression Module. Relays shall be Allen Bradley Bulletin 700, or approved equal. So called "International" and IEC rated relays will not be accepted. All relays shall be standard NEMA size.

2. General Control Time Delay Relays (non-protective control logic relays):

   a. Solid state, multi-time, and multi-function type relay. Both timing ranges and timing modes shall be field selectable. Each relay shall be capable of the following timing modes: On Delay, Off Delay, One Shot, Repeat Cycle, and Interval. Minimum relay contact rating shall be 10 amps, continuous, at 120 VAC. Coils shall be 120 VAC. Timing relays shall be Square D Class 9050 model No. JCK70 complete with Type NR61 Socket, or approved equal.

3. Mount control relays inside the upper-front-compartment (upper front bay) of each respective and applicable vertical section of the Switchgears. DO NOT mount relays directly to the sheet metal barriers within the vertical sections of the Switchgear sections. Mount relays on the white-painted backpanel (device panels) located inside the upper front-compartment of each vertical section.

D. Lockout relay:

1. Provide each circuit breaker with Lockout Relay as also shown on the PLANS. The lockout relay shall be hand reset and wired per the PLANS. Lockout relays shall be as manufactured by Electro-Switch Series 24, General Electric Company "G.E", or approved equal.

2.04 CIRCUIT BREAKER SECTIONS – DRAWOUT VACUUM CIRCUIT BREAKERS

A. Make modifications to the existing Switchgear Circuit Breaker assembly as required to implement the modifications shown on the PLANS and as required in this section of the specifications.

B. Circuit Breaker Assemblies (main, tie and feeder/branch circuit breakers):

1. As minimum, <u>Each Circuit Breaker assembly</u> shall be furnished with the number of NORMALLY OPEN (N.O.) and NORMALLY CLOSED (N.C.) circuit breaker auxiliary contacts shown on the PLANS. However, furnish one (1) additional spare NORMALLY OPEN (N.O.) and one (1) additional NORMALLY CLOSED (N.C.) breaker auxiliary contacts assembly over the number of contacts (of each type), including spare contacts, shown on the PLANS . The required pair of spare contacts applies to each type of breaker action auxiliary contacts (i.e., truck operated, mechanism operated, etc., as depicted on the PLANS). Pre-wired spare contacts shown on the PLANS and/or any additional spare contacts required herein shall be prewired to the appropriate terminal blocks/strips located in the Upper-Front-Compartments (upper front bay/cell) of the associated vertical section of the Switchgears. All mechanism operated circuit breaker auxiliary contacts shall reflect true circuit breaker open and close status positions and shall operate both when the circuit breaker is racked in as well as when the circuit breaker is racked out in the test position. All mechanism operated circuit breaker

auxiliary contacts shall reflect circuit breaker open status when the circuit breaker is racked out AND NOT in test position.

2. Switchgear manufacturer shall provide all labor and material so as to modify, at minimum, the existing circuit breaker assemblies for each existing Main, Tie, and Link Feeder breakers, for a total minimum of six (6) such breakers, so that the stationary mechanism operated circuit breaker auxiliary contacts (MOC) shall reflect true circuit breaker open and close status positions and shall operate both when the circuit breaker is racked in as well as when the circuit breaker is racked out in the test position. All mechanism operated circuit breaker auxiliary contacts shall reflect circuit breaker open status when the circuit breaker is racked out AND NOT in test position. Switchgear manufacturer shall disconnect, reconnect, and re-tag all wiring, as required, to accommodate MOC switch modifications.

2.05 INSTRUMENT AND CONTROL WIRING TERMINAL BLOCKS AND ASSOCIATED WIRING METHOD

A. Terminal Block and/or Terminal Strip:

1. Terminal blocks used 120 volts AC, 130 volts DC and 24 volts DC instrumentation and control wiring shall be NEMA Terminal Blocks, 600 volts with continuous current rating of 30-amperes, nylon or polypropylene, snap together Knife-Style isolating terminal blocks. Terminal blocks shall be mounted on a Heavy Duty DIN Rail. Terminal blocks shall be manufactured by Allen-Bradley catalog No. 1492-WKD6 (33 terminals per foot) complete with 1492-SM6X12 detachable multi-character Snap-in Marker Card, and manufacturer's insulated side jumpers, or approved equal. Use of wire as jumper between terminal blocks will not be accepted. Tag each terminal block (each point on a terminal strip). Tag of each terminal block shall be typed with an indelible marking process. Handwritten tags WILL NOT BE ACCEPTED.

2. Shorting Terminal Blocks for wiring to/from Instrument Current Transformers: Terminal blocks shall be Tap-Changing-Shorting Terminal Blocks, NEMA Terminal Blocks, 600 volts with minimum continuous current rating of 55-amperes. The Shorting Terminal Blocks (designated on the PLANS as STB's) shall be utilized for secondary wiring of all Multi-Ratio and Dual Ratio Current Instrument Transformer. The Shorting Terminal Blocks shall be as manufactured by General Electric "G.E.", or approved equal.

B. Terminal Strip/Block General Wiring Methods, Tagging and Identification:

1. Terminal strips/blocks associated with wiring of equipment within a vertical section of the Switchgears shall be located in the UPPER-FRONT COMPARTMENT (upper front bay) of the respective vertical section (lower front bay or lower compartment shall be utilized for drawout assemblies such as circuit breakers, Potential Transformers P.T.'s, and window type Current Transformers C.T.'s, etc.).

2. Each instrument and control wiring terminal block shall be in a vertical section of the Switchgears shall be mounted on a heavy-duty RAIL (DIN-RAIL mount). Each Terminal Strip within a vertical section shall be mounted on a rail that is physically isolated from any other terminal strip and associated rail in the section. All Terminal Strips must be separated from one another.

3. UNDER NO CIRCUMSTANCES SHALL ANY WIRE RUN FROM ONE DEVICE TO ANOTHER WITHOUT GOING THROUGH AND BEING TERMINATED TO A TERMINAL BLOCK. A point or multiple of points of wiring termination located at any device shall not be considered the same as a terminal point OR termination point on a Terminal Block NOR shall it be considered the same as Terminal Block(s). Also, refer to the requirements shown on the PLANS.

4. Tag each individual Terminal Block. Each terminal shall have the same tag as the tag of the wire connected to the respective terminal. Utilize the Terminal Blocks manufacturer's tagging assembly (markers, marking strip, etc.) as specified in this Section of the Specifications. All tags must be typed and neatly attached to the marking surface per the recommended procedure of the Terminal Block Manufacturer. Handwritten tags WILL NOT BE ACCEPTED.

5. Physically segregate/separate and isolate AC control wiring terminal strips and its associated DIN-RAIL mount from the DC control wiring terminal strips and its associated DIN-RAIL mount. Also, refer to terminal strip layout and arrangement shown on the PLANS.

6. Utilize the terminal block manufacturer's plated copper terminal-to-terminal insulated side jumpers for making connections between adjacent terminal blocks and/or between terminal blocks located on the same terminal strip. Use of wires as jumpers between terminal blocks will not be accepted.

7. DO NOT mount Terminal Strip assemblies (inclusive of DIN Railing, where applicable) directly to the sheet metal barriers within the vertical sections of the Switchgear sections. Mount Terminal Strip assemblies on the white-painted backpanel located inside the upper front-compartment of each vertical section.

2.06 DEVICE/COMPONENT IDENTIFICATION AND WIRE TAGGING REQUIREMENTS

A. Properly identify all devices, general control relays, CT's, PT's, CPT's, PMU's, FMR's, Pilot Lights, Terminal Blocks, terminal strips, shorting terminal blocks, breakers, auxiliary contact blocks...etc. that are located within/inside, on face, and on back (access doors/panels) of each section/compartment of the Metal-Clad Switchgears. For identification nameplates of equipment located inside/within each section of the Metal-Clad Switchgears, utilize manufacturer's standard laminated labels, "Black" with White typed lettering. Secure and attach label per manufacturer's standards. Lettering type and size shall be as such that is clear and visible and acceptable to the Owner.

B. Identify all wiring, such as control/status wiring, power wiring, instrument wiring, etc. at the terminal blocks, lugs, starter/controller/auxiliary compartments, at termination to control devices/PMU's/ FMR's/Instruments/ CT's/PT's,....etc. Each end of a wire shall be tagged with manufacturer's standard heat shrinkable wire tags. All wire tag identifications, etc. must be typed and not handwritten and shall be per manufacture's standards.

C. Provide identification strips for all terminal blocks, marked in compliance with the applicable wiring diagram drawings (as-builts). Handwritten marking on wiring and terminal blocks will not be accepted. All marking/identification of terminal blocks and wiring shall be typed and shall be per the manufacturer's standard.

D. Furnish and install laminated 3-ply “Black-White-Black”, phenolic identification nameplate for each equipment/device/etc. installed/mounted on the face of the Metal-Clad Switchgears. Lettering font shall be manufacturer’s standard with minimum lettering size of 1/4” in height. Attach nameplate with 316 Stainless Steel screws, use of adhesives shall not be accepted. Note: Each pilot and control device shall be provided with a function and device Name-Tag identification nameplate in addition to the device manufacturer’s legend plate

E. Properly identify each section and compartment of the Metal-Clad Switchgears. For identification nameplates, utilize laminated 3-ply phenolic, “Black-White-Black”, plastic laminated nameplates, a minimum of 3/32” thick, with white lettering on black background. Lettering font shall be manufacturer’s standard. Attach nameplate with 316 Stainless Steel screws. Minimum lettering size of identification nameplates pertaining to section/compartment content and name identification in the Metal-Clad Switchgears shall be 3/8” in height

F. For devices mounted on the face of the doors of the Metal-Clad Switchgears, install identification nameplate on the back side of the doors in addition to the nameplates installed on the front face of the Metal-Clad Switchgears. Nameplates installed on the back side of the doors shall be per the requirements of paragraph-A (above) of this subsection.

PART 3 - EXECUTION

3.01 FIELD INSTALLATION

A. Perform Switchgear modifications in accordance with manufacturer’s written guidelines, the NEC, and local codes.

B. Refinish all painted steel work that was damaged during Switchgear modification activities. Finish shall match the existing Switchgear.

3.02 FIELD TEST AND CHECKS

A. Inspect completed installation for physical damage, proper alignment, anchorage, and grounding.

B. The following minimum test and checks shall be made before energizing the Switchgear. These tests shall be performed by a Factory Trained Field Technician (non-sales type).

1. Calibrate, adjust, set, and test all protective devices and metering units according to settings provided and required by subsection 1.08 “Special Manufacturers Services”.

2. Submit documentation of all tests outlined above. Include all test documentation data in operation and maintenance manuals.

3. Adjust all operating mechanisms for free mechanical movement per manufacturers Specifications.

4. Tighten bolted bus connections in accordance with manufacturer's instructions, as applicable.

3.03 EQUIPMENT PROTECTION AND RESTORATION

A. Clean and vacuum clean all interior of the equipment.

B. Touch-up and restore damaged surfaces to factory finish.

3.04 MEASUREMENT AND PAYMENT

A. No separate measurement or payment for work performed under this Section, except as indicated below. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

SECTION 16080

DIRECT CURRENT "DC" POWER STORAGE, CHARGING "DC" DISTRIBUTION AND INVERSION SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

A. Provide all labor, materials, equipment, and incidentals required to design, furnish and install the Direct Current (DC) system assemblies complete with all specified accessories as specified herein and as shown on the PLANS.

B. A single DC Power Storage, Charging, DC Distribution and Inversion Systems Supplier/Contractor/Installer (DCISS) shall furnish and install all services and equipment defined herein and in other Specification Sections as listed below under Related Requirements. These services include but not limited to furnishing the design, equipment, installation, calibration, programming, checkout, documentation, maintenance, etc. for the DC Systems as specified herein and as shown on the PLANS. The DCISS shall have the qualifications as described in subsection 1.03, "DCISS Qualifications", this Section of the Specifications.

1.02 RELATED REQUIREMENTS

A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.

B. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.

C. The PLANS designate the type, number, size and rating of devices included in the equipment and assemblies specified herein.

D. Comply with the requirements of Division-16 and Division-17 of the Contract Specifications, and the Contract Documents.

E. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

F. Provide the complete, workable, and installed-in-place DC Systems as specified herein and as shown on the PLANS. The DC systems shall be designed, furnished, installed, and started up by the single DCISS firm.

1.03 DCISS QUALIFICATIONS

As minimum the DCISS firm to have the following:

A. The DCISS firms shall have in-house engineering capability to prepare all necessary component drawings, system drawings and installation, operations and maintenance manuals.

B. The DCISS firm shall have in-house engineering capability for the coordination design and selection of all components in the Direct Current "DC" Power Storage, Charging, "DC" Distribution and Inversion Systems. It is also understood that the DCISS firm shall review all the component and specifications and prepare detailed purchase orders that will assure the proper features are furnished on each component and that will comply fully with the requirements of the Contract Specifications and function as required in the individual systems.

C. The DCISS firm shall have a minimum of ten (10) years experience designing, manufacturing and installing complete Direct Current "DC" Power Storage, Charging, "DC" Distribution and Inversion Systems for Substations and Industrial Facilities that are similar in scope and value as proposed for this project.

D. The DCISS firm shall furnish a list of the design personnel and installation technicians who will be assigned to this project. The DCISS firm shall have an electrical engineer on staff. The engineer must be registered professional engineer in the State of Texas. The qualifications for each of the above persons shall be included for review by the Engineer and Owner.

E. The DCISS Firm Site Representative: Minimum of 8 years experience installing similar systems as those required for this project.

F. The DCISS Firm Start-up and Testing Team Members: Minimum of 3 years experience in testing systems similar to those required for this project.

G. The DCISS firm shall furnish sample drawings, purchase orders, installation instructions and operating and maintenance manuals that he/she has prepared on previous projects for review by the Owner and Engineer.

H. The DCISS shall be a "DC/AC power systems house" and/or power distribution system equipment manufacturers OEM, regularly engaged in the design and the installation of AC/DC power supply Systems and their associated subsystems as they are applied to the Medium and High Voltage Type of Industrial Power Distribution Systems industry.

I. The DCISS shall maintain a fully equipped office/production facility with full-time employees capable of fabricating, configuring, installing, calibrating, troubleshooting, and testing the system specified herein. Qualified repair personnel shall be available and capable of reaching the facility within a 24 hour period.

J. The DCISS shall furnish equipment which is the product of one manufacturer to the maximum practical extent. Where this is not practical, all equipment of a given type shall be the product of one manufacturer.

K. DCISS firms that wish to provide these services on this project shall prepare a qualifications package that shall be submitted to the Owner/Engineer for approval. This qualifications package must demonstrate DCISS's experience in Paragraphs 1.03A through 1.03J herein, which shall be subject to review by Owner/Engineer. The Owner will make the final determination of whether or not the DCISS meets the minimum capabilities, experience criteria, and staff and facility requirements as specified herein. All decisions will be final.

1.04 SUBMITTALS

A. Shop Drawing Submittals

1. Submit complete shop drawings and engineering data for review per the requirements of Section 01300 of the Specifications. At minimum, shop drawings data shall include the following:

a. For the equipment/system specified in this section, submit (as minimum):

1) One-line, three-line, and wiring diagrams.

2) Dimensioned/scaled top and bottom views, front elevations, sectional views, and internal component/device layouts. Include overall weight for each section/equipment.

3) Catalog cut sheets on all materials. Include family of protective device curves (fuse, breaker, etc.) and also peak current limiting protective device curves where applicable.

4) Material safety data sheets

5) Prior to shipment of the equipment to the project site, submit certified factory test reports as described in Subsection 3.01, this Section of the Specifications.

6) All required technical information for the reporting/permitting of hazarous materials in the Direct Current (DC) system, including, but not limited to, the chemical/product name, quantity, NFPA 704 health rating, NFPA 704 fire rating, and NFPA 704 reactive rating for each hazardous element in the Direct Current (DC) system as required by the reporting requirements of the Authority Having Jurisdiction.

B. Operation and MAINTENANCE MANUALS

1. Submit operation and maintenance manuals per the requirements Section 01730 of the Specifications. At minimum, the manuals shall include the following:

a. Contents:

1) Installation and operation manuals

2) Lubrication and maintenance instructions.

3) Test data and performance curves, where applicable.

4) Approved shop drawings.

5) CD-ROMs of all software, drivers, etc.,

6) Protective Device Settings accompanied by associated field calibration, test and setting data, and Manufacturer's Certification Reports.

C. Pre-submittal conference

1. General:

a. Review the manner in which the contract requirements will be met prior to preparation of submittals. The Contractor, Engineer, Owner, and DCISS shall attend. Schedule, conduct, and arrange the conference within 90 calendar days after receipt of written notice to proceed work is given by the Owner.

b. The DCISS shall present the following at the conference:

1) List of equipment and major accessories (timing relays, etc.) required and the brand that shall be used for each item

2) Sample submittals from similar projects including the types of drawings/data specified herein

1.05 QUALITY ASSURANCE

A. Equipment and assemblies specified under this section shall be designed, constructed, and tested in accordance with the latest applicable requirements of ISA, NEMA, ANSI, UL, EIA, IEEE, and NEC standards. Coordination with OSHA and the City of Austin Fire Department is required.

B. Construct assemblies in DCISS facility. Test assemblies for proper operation prior to shipment to the project site.

1.06 DELIVERY, STORAGE AND HANDLING

A. Protection:

1. The DCISS shall be responsible for safety of the equipment during storage, transporting and handling.

2. The equipment shall have weatherproof non-porous extra heavy duty plastic covers at all times, until they are ready for test and start-up.

3. Energize the space heaters within the equipment and energize during storage and installation for humidity control.

4. Unload and handle equipment by suitable methods that are recommended and approved by the manufacturer of the equipment.

B. Additional project job site storage requirements: Upon delivery to the project site and prior to final installation, protect and store in accordance with the following:

1. Environmentally protected and stored in climate controlled (temperature, humidity, and non-corrosive class) environment at the job site. Size, furnish and install temporary gaseous air scrubbers, air conditioners, and additional environmental control equipment complete with branch circuiting conduit/wire as required to maintain in a controlled environment at the following conditions:

a. Ambient Dry Bulb Temperature:

1) Minimum: 68 degrees Fahrenheit.

2) Maximum: 85 degrees Fahrenheit.

b. Ambient Relative Humidity: Maximum: 50%.

c. Ambient Corrosion Level: International Society of Automation Class: G1

2. Every effort shall be made to provide all necessary electrical power connections ready for immediate connection to equipment upon arrival of equipment on jobsite.

3. Upon arrival of equipment onto job site, a maximum of one day shall be allowed for equipment to be left without to allow proper transition of power of equipment, especially any 120 VAC powered equipment, to ensure all air conditioning, heating, and gaseous air scrubbing equipment are fully operational with a maximum of a 10 minute down time during this transition of power.

4. Furnish and install replacement air scrubber media, air filters, etc., as required for proper operation of the environmental control equipment.

1.07 WARRANTY

A. Extended Warranty and Preventative Maintenance Contract

1. DCISS shall furnish the OWNER with a five (5) year full warranty certificate which shall be issued to the OWNER by the manufacturer of the equipment specified under this section. The warranty shall be a full service, replacement and repair type warranty, that includes all travel, lodging, expenses, labor, and parts associated with all necessary repairs. The warranty shall be provided at no additional cost to the OWNER.

1.08 TOOLS AND SPARE PARTS

A. Furnish the following spare parts with the equipment for the DC system in conformance with the specifications:

1. Three (3) – spare fuses of each type and size.

2. Two (2) – 600 volts fuse tong tool.

3. Twenty Four (24) – Neutralizing and Absorbent pillows

4. One set (minimum 3) of Circuit Breaker Overcurrent Protection Devices for each type and size used.

5. Twenty (20) terminal blocks of each color and type used.

6. Four (4) control relay assemblies for each type used. Each assembly shall be fully assembled and furnished complete with:

   a. The relay coil,

   b. Four(4) Normally Open (N.O.) contacts, and

   c. Four(4) Normally Closed (N.C.) contacts.

   d. Relay Manufacturer's Transient Voltage Suppression Module.

7. Four (4) Timing relays, each complete with the relay socket base assembly, for each type used.

1.09 SPECIAL DCISS SERVICES

A. Furnish the services of a qualified, experienced, factory trained technical (non-sales type) representative to assist in the installation of the equipment. Include checking alignment of parts, wiring connections, operation of all parts (relays, battery chargers, inverters, etc.). Include time to correct and re-check any discrepancies which are discovered. Also include providing the OWNER with a report certifying that the equipment was installed properly tested and set in accordance with the specifications and is in satisfactory operating condition. Format and quantity of reports shall be per the requirements of Section 01300 of the Specifications.

B. DCISS is to set, adjust and test all circuit breakers, etc., in the presence of an Owner representative. Additionally, the DCISS will select the characteristics of the protective devices that are most suitable for the system in providing proper protection and coordination. The settings will be based on coordination and short circuit studies performed in compliance with Section 16044 of the Specifications, paragraph 1.09 "Special Manufacturer's Services". Provide the OWNER with test report certified by the DCISS. Include a record of all settings. Format and quantity of reports shall be per the requirements of Section 01300 and Section 01730 of the Specifications. The DCISS shall furnish the protective device of the appropriate characteristics selected by the OWNER that shall be the most suitable for the proper protection and coordination of the system at No Additional Cost to the OWNER.

C. Work in conjunction with the project's Instrumentation and Control System Contractor "PICS" as defined in Section 17100, the Electrical Contractor, Division 16 Equipment Manufacturers, and the OWNER/ENGINEER during start-up of all the systems furnished and installed by the DCISS to ensure that all interconnections between other

equipment/systems and the DCISS furnished assemblies are in satisfactory operating condition to the OWNER /ENGINEER.

D. Any problems encountered with the operation of equipment, parts, components, etc. installed within the assemblies furnished by the DCISS shall be repaired/remedied by the DCISS's technical representative.

1.10 REPORTING OF DIRECT CURRENT (DC) SYSTEM HAZARDOUS MATERIALS TO THE AUTHORITY HAVING JURISDICTION

A. The CONTRACTOR shall assist the OWNER in completing all forms required by the Authority Having Jurisdiction with regard to the reporting/permitting of hazardous materials as they may relate to the proposed Direct Current (DC) system. This assistance may include the electronic entry of information by the CONTRACTOR onto the forms, as directed by the OWNER.

B. The DCISS shall provide all required technical information for the purpose of reporting/permitting of hazardous materials to the Authority Having Jurisdiction including, but not limited to, the chemical/product name, quantity, NFPA 704 health rating, NFPA 704 fire rating, and NFPA 704 reactive rating for each hazardous element in the Direct Current (DC) system as required for complying with the reporting requirements of the Authority Having Jurisdiction.

C. The CONTRACTOR shall inform/schedule and coordinate with the OWNER to complete forms related to the reporting/permitting of hazardous materials to the Authority Having Jurisdiction in a timely manner as required for all inspections required by the Authority Having Jurisdiction for this WORK. Allow the OWNER a minimum of eight (8) weeks to complete any portions of the forms related to the reporting/permitting of hazardous materials that require input from the OWNER. Coordinate and schedule with the OWNER accordingly.

PART 2 - PRODUCTS

2.01 GENERAL

A. Provide all necessary components and wiring for a complete and functional system. Provide additional requirements as follows:

1. Provide enclosures as hereinafter specified and as shown on the PLANS to house the DC system assembly subcomponents. Mount and wire all components inside of each enclosure unless shown/specified otherwise. Each enclosure, with all components mounted and wired, complete with all accessories, shall be referred to hereinafter as a DC System Assembly Enclosure (DCSAE).

2. For additional construction notes and special requirements, refer to the PLANS and the Specifications.

B. Wiring

1. Provide wiring as specified in Section 17200 with the following exceptions:

   a. Minimum acceptable size shall be #10 AWG.

   b. Wiring colors shall be as follows:

Wiring Function	**Wire Jacket Color**
Wiring for 120 volts A.C. control	Red
Wiring for 125 volts D.C. control	Blue
Wiring for 125 volts D.C. and 120 volts A.C. alarms	Yellow

2. Group conductors and route in wireways as specified in Section 17200. Secure wiring to hinged doors and panels to the enclosure with flexibility provided around hinges to prevent fatigue and eventual breaking. Wrap such wiring with flexible spiral wrapping per the requirements of Section 17200.

C. Identification

1. Identification: Tag enclosure, terminal blocks, and devices (mounted interior and on the face of the enclosure) as specified in Section 17200. Exception: Color of phenolic nameplates shall be Dark Blue-White-Dark Blue.

2. Tag all wiring per the requirements of Section 17200.

D. Grounding: Provide isolated and non-isolated grounding per Section 17200.

E. Miscellaneous Accessories

1. Provide lugs/ power distribution blocks /terminal blocks as required for the connection of the field wiring shown on the PLANS. Provide terminal blocks per Section 17200.

2. Provide key interlocks where required by the PLANS.

3. Coordinate layout of enclosure internal components with the conduit entry requirements shown on the PLANS.

4. Provide overcurrent protection for 120 volts A.C. control/alarm circuits using the protective devices per Section 17200.

5. Provide AC control relays per Section 17200 Type I Relays. Coordinate relay type provided with the requirements of the connected equipment and the wiring recommendations of the manufacturer.

6. Provide thermostatically controlled exhaust fan complete with filtered louver as required by the PLANS. Provide per the requirements of Section 17200.

7. Provide Freestanding Cabinets/Panels in the proposed Substation per the requirements of Section 17200.

8. Coordinate with Switchgear manufacturer for the installation of the Substation Management Relay. Refer to Section 16044.

2.02 DC SYSTEM ASSEMBLY ENCLOSURE REQUIREMENTS

A. Each enclosure shall be suitable for indoor use, NEMA-1, non-walk-in type, dead front, completely enclosed, manufacturer's standard unitized metal enclosed indoor type free standing self-supporting structure.

B. Each vertical section shall have overall outer dimension of 24 inches wide, 30 inches deep, and 84 inches tall, unless shown otherwise on the PLANS. Each vertical section shall be sub-divided into multiple compartments. Refer to the PLANS for additional dimensional requirements. Internal supports shall be suitably spaced for EIA standard 23 inch wide rack mountable equipment.

C. Each enclosure shall be totally enclosed with removable panels as follows:

1. Rear Panels Type: Perforated Ventilation

2. Side Panels Type: Perforated Ventilation

3. Tope and Bottom Panels Type: Solid, equipped with knockouts for conduit connection.

D. The front of each compartment shall have a hinged door with latching means.

E. Furnish and install enclosure manufacturer's heat shield and heat baffle between each compartment.

F. Each compartment containing a circuit breaker shall have a padlockable disconnect operating handle of the standard product of the circuit breaker manufacturer. Include provisions for up to three padlocks. Handle shall be mechanically interlocked with the door to prevent personnel from opening the door when the unit disconnect is in the ON position. Provide handle-door interlock defeating (bypass) feature.

G. Mounting channels, interior device back/side panels, 600 volt stand-off isolators, brackets, filler plates, wireways, hardware, accessories, etc. shall be provided to facilitate the mounting of devices. Mount all terminal blocks on interior device panels. Interior panels shall be painted white.

H. Structure finish shall be primed and painted using the manufacturer's standard finishing process. Finish shall be applied at the manufacturing plant. Color shall be manufacturer's standard.

I. Manufacturer: Hoffman, or equal by C&D Technologies, Bulletin 10-450 "Box Frame Enclosures" with all specified accessories, or approved equal.

2.03 BATTERY CHARGER

A. General:

1. AC Input Voltage: 480 volts A.C. plus or minus 10 percent, single phase

2. AC Input Current: 22 ampere, maximum

3. Input Frequency: 60 Hz plus or minus 5 percent.

4. DC Output Voltage: 130 volts D.C.,

5. DC Output Current: 50 ampere. However, the DC charging current rate shall be limited to disallow thermal runaway for the provided battery system. Coordinate with battery manufacturer for limiting maximum charging current rate as required by the battery manufacturer. The charger system shall include a listed device that shall preclude, detect, and control thermal runway for the installed DC system.

6. Float Voltage Range: 120 – 142 volts D.C.,

7. Float Voltage Setting of 132 volts D.C.

8. Equalize Voltage Setting: 140 volts D.C.

9. Float and equalize voltages are continuously field adjustable over the voltage range

10. Topology: Controlled ferroresonant transformer with full wave rectifier

11. Operating Temperature Range: 0 to 50 degrees Celsius

12. Output Ripple Voltage: 30 millivolts RMS, maximum

13. Regulation: +/- 0.5% at full load at float

14. Input Protection: Two pole thermal magnetic circuit breaker

15. Output Protection:

    a. Two pole thermal magnetic circuit breaker

    b. Current limiting Circuit: Limits to 110 percent of full load rated current, field adjustable over range of 80 to 110 percent of full load rated current.

16. Alarm Contact Ratings: 2 amperes at 30 volts D.C., 0.6 amperes at 125 volts A.C. Provide alarm contacts as shown on the PLANS.

17. Mounting: Rack mountable, install in a DCSAE as shown on the PLANS. Exception: A door on the front of the battery charger is not required.

18. Accessories:

    a. Analog indication of output voltage and ampere

b. Equalize Timer: Field settable between 0- 72 hours.

c. Lightning Protective Device on charger AC input

d. Blocking diodes

e. Load sharing to accommodate simultaneous operations of multiple chargers

f. Float voltage temperature compensation circuit: Monitor temperature of battery bank ambient to adjust charger operation. Include field temperature sensor with integral cable. Coordinate cable length required with the PLANS.

B. Manufacturer: UNIPOWER, LLC "Single-Phase, Controlled Ferroresonant ARE-M series FLOAT RECTIFIERS", 130 volts DC Model with all specified accessories, or approved equal.

2.04 250 VOLT DC MOLDED CASE CIRCUIT BREAKERS

A. Provide thermal magnetic molded case circuit breakers per Section 16500 "Panelboards".

2.05 "DC" TO "AC" INVERTER

A. General:

1. DC Input: 105 to 145 volts D.C., nominal input voltage is 120 volts D.C..

2. AC Input: 240/120 volts "AC" plus or minus 10 percent, 60 Hz plus or minus 1.5 Hz.

3. AC Output: 120/240 volts A.C., 60 Hertz, split phase

4. Power: As shown on the PLANS.

5. Topology: Pulse-width modulation type with internal static bypass switch. Internal static bypass switch with shall automatically bypass the inverter upon loss of the "DC" input and transfer the connected loads to an external "AC" source of power within 4 milliseconds. Inverter shall also have integral circuit breakers for DC Input and AC output.

6. Operating Temperature Range: 0 to 40 degrees Celsius

7. Regulation: +/- 1%

8. Efficiency: 89 % at full load

9. Load power factor: 0.8

10. Overload: 120 % for 10 minutes without damage. Integral overload protection.

11. Alarm Contact Ratings: Contacts rated 0.5 ampere at 120 volts A.C. Provide alarm contacts for system common failure and for low DC voltage as shown on the PLANS.

12. Mounting: Rack mountable, install in a DCSAE as shown on the PLANS. Exception: A door on the front of the inverter is not required.

13. Accessories:

    a. Digital indication of voltage, ampere and frequency for:

        1) Inverter Input

        2) Invert Output

        3) Inverter AC Bypass,

        4) Overall system.

    b. Manufacturer's keypad and 20 character x 4 line LCD display

    c. External break-before-make type maintenance bypass switch.

    d. Draw-out handles mounted on the face of the inverter

    e. Furnish and install all field sensor interconnect leads/wiring. Coordinate length with the requirements of the PLANS and connect per manufacturer's recommendations.

B. Manufacturer: Philtek Electronics, Model Hpi, complete with all accessories, or approved equal.

2.06 DC POWER DISTRIBUTION BUS

A. DC Power Distribution Bus Section shall be dedicated to terminating multiple incoming lines and circuit breakers as also shown on the PLANS. The addition of supplementary parts/equipment and other customization by the DCISS is required and shall be provided at not additional cost to the OWNER.

B. Provide Power Distribution Panelboard per Section 16500 "Panelboards".

2.07 BATTERY BANK

A. General requirements for each battery cell:

1. Type: Valve regulated lead acid "Lead Calcium" sealed type

2. Ampere-Hour rating: 640, minimum

3. Number of positive plates: seven (7)

4. Electrolyte specific gravity: 1.25

5. Float voltage: 2.2 to 2.3 volts per cell at 77 degrees F

6. Maximum physical overall dimensions: 23.13 inches deep x 8.9 inches high x 5.9 inches wide

7. Maximum cell weight: 132 pounds.

B. General requirements of each battery module:

1. Number of battery cells: six (6)

2. Mounting: Manufacturer's standard steel tray mounting system complete with battery cell spacer plates. Provide spacer plates between every two cells.

3. Module terminal voltage: 12 volts DC minimum, 13 volts DC maximum

4. Eight hour capacity: 640 ampere-hour at full load

5. Maximum physical module overall dimensions: 26 inches deep x 10 inches high x 40 inches wide

6. Maximum module weight: 920 pounds.

7. Interconnect modules/cells using manufacturer's standard tin-plated intercell connectors.

C. Battery Racking System

1. General: Previously specified Battery Modules shall be stacked utilizing the battery manufacturer's standard height base and rack system to form a Battery Rack. The total number of Battery Modules required shall be evenly divided into a total number of two (2) Battery Racks required for this project, as also shown on the PLANS.

2. General Requirements for each Battery Rack is as follows:

a. Five (5) battery modules as previously specified

b. Heavy steel rack base.

c. Solid steel back and side panels for each rack.

d. Front clear PVC manufacturer's safety shield shall that cover the face of all battery modules contained in the rack.

e. Battery cells shall be draw-out.

f. All steel shall be finished per manufacturer's standard for optimal corrosion resistance.

g. Maximum physical rack overall dimensions: 26 inches deep x 55 inches high x 40 inches wide.

h. Maximum rack weight: 4600 pounds..

3. Interconnect battery racks using manufacturer's standard insulated bus type connections.

D. Manufacturer: C&D Technologies Model msEndur II with Model AT- batteries, complete with all accessories, or approved equal.

2.08 BATTERY MONITOR

A. General:

1. Type: Microprocessor based technology

2. Function: Monitor and manage data with test, analysis, and remote monitoring and control capabilities.

3. Application: Suitable for use on 130 volts D.C. battery bank system application

4. Power Supply: Rated for 130VDC power supply input, as shown on the PLANS. Furnish and install two pole DC control circuit breaker, per this section of the specifications, located in the battery monitor enclosure. The breaker is to serve as disconnecting means for the battery monitor.

5. Operating Temperature Range: 41 degrees F to 104 degrees F

6. Setpoints: Field adjustable.

7. Local Indication: Provide LED indications of alarms, communication, and processor status.

8. Mounting: Rack mountable, install in a DCSAE as shown on the PLANS. Exception: A door on the front of the battery monitor is not required.

9. Output Contact: Provide two alarm output contacts for high temperature and for system fail rated 2 amperes at 30 volts D.C. as shown on the PLANS.

10. Accessories: Furnish and install all field sensor interconnect leads/wiring. Coordinate length with the requirements of the PLANS and connect per manufacturer's recommendations.

B. Monitor, detect, and analyze the following variables:

1. Individual Battery Cell voltage

2. Individual Battery Cell temperature

3. Individual Internal Battery Cell resistance

4. Float current of battery string

5. Discharge time.

6. Battery float voltage of battery string

7. Midpoint voltage of battery string

8. Two (2) ambient temperatures, one for each rack

9. Differential Temperature between entire battery banks.

C. Provide the following alarms, at minimum:

1. Open lead

2. High voltage

3. Low voltage

4. float current high

5. Battery bank failure

6. Monitoring system failure

7. High temperature

D. Software:

1. Provide with all necessary Communication System Application and System Software and drivers.

2. Provide with system historical log per manufacturer's standard.

3. All software shall be Windows compatible.

E. Communications:

1. TCP/IP Ethernet port RJ-45 with Ethernet option card. Provide Ethernet communication capability. Connect as shown on the PLANS. In particular, the unit shall have all drivers and accessories to allow it to communicate with the DCS system over Modbus TCP/IP protocol.

2. The device shall have a second, dedicated TCP/IP Ethernet port RJ-45 with Ethernet capability that is dedicated for programming purposes only. This Ethernet port shall be separate from that port used for communicating with the DCS.

3. All alarms and monitored data shall be available through the communication interface.

F. Manufacturer: Sentinel Battery Monitor as manufactured by PowerShield, or approved equal with a wall plug transformer to accommodated needed unit power.

2.09 BATTERY BANK ENVIRONMENTAL COMPLIANCE AND SAFETY EQUIPMENT

A. Floor Protection:

1. Type: Chemical Resistant Epoxy Floor Coating

2. Application: Coat entire region under batteries plus and additional 24 inches around the perimeter of the battery racks

3. Manufacturer: Enviroguard, or approved equal.

B. Spill Containment:

1. Type: Modular, 4 inches high metal coated with acid resistant PVC.

2. Application: Install at 12 inches outside the outer perimeter of the battery racks.

3. Finish Color: Safety Yellow

4. Manufacturer: Enviroguard model EGS, or approved equal..

C. Neutralizing and absorbent pillows:

1. Size: 12 inches x 12 inches, minimum, additional sizes as required for coverage

2. Application: Provide quantity as required to pack spill containment area full per applicable Codes and Regulations. Additionally, install in draw-out trays in area beneath battery racks, as specified hereinafter.

   a. At a minimum, the method and material shall be capable of neutralizing a spill of 10 percent of the capacity of the largest cell or block in the room to a pH between 5.0 and 9.0 and per additional requirements per applicable Codes and Regulations.

3. Manufacturer: Enviroguard model Neutralizing and Absorbent Pillows, or approved equal.

D. Spill Containment Draw-out trays:

1. Application: Furnish and install draw-out tray underneath each battery rack. Each tray shall contain previously specified neutralizing and absorbent pillows. Tray height shall be between 3 and 4 inches, with the width and depth to be equal to or greater than battery rack. Coordinate final size of tray with battery rack dimensions.

2. Material: Type 332 Stainless Steel

3. Manufacturer: Enviroguard or approved equal..

E. Safety and Medical Kits:

1. Furnish and install two (2) sets of complete Battery Area Safety and Medical Kits that shall meet and exceed the requirements of the applicable Codes and Regulations. Each kit shall include the following at minimum:

   a. Chemical Splash Goggle

   b. Eye Irrigator in a squeezable bottle for eye flushing. Fill the bottle complete with distilled clear water.

c. Acid Neutralizing soda.

d. Polyvinyl plastic APRON which shall be chemically resistant, very flexible, non-sticking, strong, but light in weight, translucent.

e. Small, Medium, and Large size band-aid, a supply of 100-count per size (and per KIT).

f. Safety Kit Equipment Wall Mounting Medical Cabinet. The cabinet shall a heavy-duty fiberglass gasketed cabinet. The cabinet shall be manufactured specifically for use as a chemical area SAFETY AND MEDICAL KIT. The inscription of Medical and Safety Kits shall appear on the face of the cabinet door. The cabinet shall have a safety YELLOW finish.

2. Accessories:

a. Furnish and install two (2) sets of face shields. Each Face Shield shall protect the entire face and shall be equipped with replaceable sweatband and polycarbonate visor. The Face Shield shall be the supply of Southwestern Battery Company Incorporated, or approved equal.

2.10 CONTROL AND PILOT DEVICES

A. Selector Switches:

Provide selector switches with the contact operation type (maintained action, momentary action, etc.) where shown on the PLANS. Switches shall be as manufactured by General Electric “G.E.” Type SB1, Electro-Switch, or approved equal.

B. Indicating Pilot Lights:

Indicating lights shall be NEMA Style, full size 30-millimeter (30mm), Transformer Type Light Emitted Diode (LED), NEMA 4/13 oil tight and watertight, full size, push to test type, rated at 120VAC or 130VDC, as applicable (refer to PLANS), with legend plate marked as shown on the PLANS. Lens color shall be as shown on the PLANS. Pilot lights shall be as manufactured by Allen-Bradley Bulletin 800T NEMA Type 4/13, oil tight and water tight, or approved equal. Miniature size pilot lights will not be accepted.

C. Control Relays:

1. General Control Relays (control logic relays):

General control logic relays, where required, shall be 600 volt AC and/or DC, as applicable). Minimum contact rating shall be 10 amperes continuous at the rated operating voltage and voltage type (AC or DC). Furnish each relay with one additional Normally Open (N.O.) and one additional Normally Closed (N.C.) contacts over the number required by the schematic diagrams. Relays shall be furnished with visual mechanical latch-unlatch indicators. Additionally, coil of each relay shall be furnished with Relay Manufacturer’s Transient Suppression Module. Relays shall be Allen Bradley Bulletin 700. So called "International"

and IEC rated relays will not be accepted. All relays shall be standard NEMA size.

2. General Control Time Delay Relays (non-protective control logic relays):

   Solid state, multi-time, and multi-function type relay. Both timing ranges and timing modes shall be field selectable. Each relay shall be capable of the following timing modes: On Delay, Off Delay, One Shot, Repeat Cycle, and Interval. Minimum relay contact rating shall be 10 amps, continuous, at 120 VAC. Coils shall be 120 VAC. Timing relays shall be Square D Class 9050 model No. JCK70 complete with Type NR61 Socket, or approved equal.

D. "DC" Control Logic Breakers

1. Circuit breaker type and interrupting shall be as follows:

   a. Circuit breakers shall be 250 Volts DC (per pole), thermal magnetic molded case circuit breakers with continuous current rating as required to protect and serve load (at the operating voltage of the system). Breakers shall operate continuously, without tripping, when operating/running current is equal to 80% of the long time trip setting (or frame rating, as applicable) of the breakers.

   b. Circuit breaker shall be two (2) poles, 500 volts DC, with a maximum continuous current carrying capacity as required to serve load and a U.L. listed minimum RMS symmetrical short circuit current rating equal to or greater than 10,000 amperes at the operating voltage of the system (130 volts DC). Breakers shall be U.L. listed.

   c. Breakers shall be the Bulletin 1492-D Miniature Circuit Breakers as manufactured by Allen Bradley.

2. Furnish and install 2 phase bus for DC voltage power distribution amongst breakers.

   a. DC bus shall have a minimum 80A continuous rating.

   b. Furnish and install Bus bar accessories, inclusive of Terminal Power Feed, Dedicated Power Feed, End Cover for bus bar, and Protective Shroud for each unused pin

   c. Bus bar and all accessories shall be as manufactured by Allen Bradley for the specified breaker.

E. Fiber Optic Patch Panel: Corning Fiber Patch Panel Model SPH-01P fiber patch panel with connector panel consisting of Six (6) SC-Duplex single-mode connectors. Mount patch panel onto the back plane and allow space and wireway for routing of fiber optic cables to/from each patch panel. Refer to Section 17600 for fiber connector requirements. Tag patch panel and refer to Section 17600 for additional patch panel requirements.

F. Fiber Optic Patch Cords: DCISS shall furnish and install single-mode fiber optic patch cords with connector ends as needed to mate between the Substation Management Relay inter-relay communication module and the fiber patch panel. Refer to Section 17600 for fiber optic patch cord requirements.

G. Copper Patch Panel: For each Substation Management Relay unit with Copper Ethernet Communication, furnish and install a dedicated patch panel for termination of the Copper Ethernet data highway (serial communication) cabling for each management relay. Copper Patch panels shall be two-port, surface mounted, fully enclosed type, Category 6A, with RJ-45 connectors, as manufactured by "Panduit", Model Mini-Com #CBXJ2IW-A, with "Mini-Com TX6A" UTP Coupler Module Model CJ6X88TGIW and blank cover plates, or approved equal. Ethernet patch cords shall be furnished and installed between the patch panel and the respective protective relay/power monitoring unit per the requirements of Section 17600 "Distributed Control System".

H. Copper Ethernet Patch Cords: DCISS shall furnish and install copper Ethernet patch cord with connector ends as needed to mate between the Substation Management Relay Copper Ethernet communication module and the copper patch panel. Refer to Section 17600 for copper Ethernet patch cord requirements.

2.11 SUBSTATION CONTROL PANELS

A. Furnish and install control panels "SUB1-CP-002" and "SUB2-CP-002" and all equipment therein, with exception of Substation Management Relay which shall be furnished by Switchgear manufacturer and installed by DCISS. Refer to PLANS for additional information. Closely and carefully coordinate the Substation Management Relay with Switchgear manufacturer.

B. Each control panel shall be a free standing enclosure, with all wiring, wire duct, component arrangement, fans, lights, and receptacles per Section 17200.

C. For each Substation Management Relay fiber optic communications, DCISS shall furnish and install fiber optic patch panels and patch cords in accordance to this section of the specifications. ICS shall be responsible for furnishing and termination of fiber cable from outside the control panels to patch panels inside each control panel and associated fiber cable testing, per Section 17600. DCISS shall closely and carefully coordinate fiber optic cable requirements with ICS, inclusive of bending radius, needed space in panel for cable routing, etc.

D. For each Substation Management Relay copper Ethernet communication, DCISS shall furnish and install copper patch panel and copper Ethernet patch cord in accordance to this section of the specifications. ICS shall be responsible for furnishing and termination of copper Ethernet cable from outside the control panels to copper patch panels inside each control panel and associated copper Ethernet cable testing, per Section 17600. DCISS shall closely and carefully coordinate copper cable requirements with ICS, inclusive of bending radius, needed space in panel for cable routing, etc.

PART 3 - EXECUTION

3.01 FACTORY TESTING (BY EQUIPMENT MANUFACTURER)

A. Standard factory tests shall be performed on the equipment specified in accordance with the latest version of ANSI and NEMA standards. The manufacturer shall provide certified

copies of factory test reports prior to shipment of the equipment to the project site. Format and quantities of the test report shall be in accordance to Section 01300 of the Specifications.

3.02 DCSAE ASSEMBLY (BY DCISS)

A. Comply with the panel assembly requirements of Section 17200. Exception: The ICS required by Section 17200 shall be the DCISS.

3.03 FIELD INSTALLATION

A. Install per manufacturer's instructions and recommendations. Install all required safety labels.

B. Perform special manufacturer's field services as previously specified per subsection 1.09, this Section of the Specifications.

C. Prior to installing the battery system, apply the previously specified floor protection coating and install the spill containment.

3.04 EQUIPMENT PROTECTION AND RESTORATION

A. Clean and vacuum all interior of the equipment.

B. Touch-up and restore damaged surfaces to factory finish.

3.05 FIELD ADJUSTMENTS AND TESTING

A. Set, adjust, and test all protective devices based on the results of the coordination study.

B. Perform the following tests:

1. Megger terminals and buses for grounds, test per manufacturer's recommendations

2. Calibrate, set, and adjust all equipment and test all equipment/system interconnections.

3. Verify proper operation of all equipment and the overall system.

4. Test for proper phasing of power connections. Check phasing across and the DCISS and connecting feeders phasing sticks, where applicable.

5. Verify proper phase rotation.

6. Test key interlock system for proper functionality, where applicable.

7. Check tightness of accessible bolted bus joints using calibrated torque wrench per manufacturer's recommended torque values.

C. Submit documentation of all tests outlined above. Include all test documentation data in Operation and Maintenance Manuals.

3.06 DCISS CERTIFICATION

A. The DCISS shall provide a report certifying in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations and are in proper working order.

B. Format and quantity of Certification Reports shall be per the requirements of Section 01300 and 01730 of the Contract Specifications. Also, refer to Subsection 1.09 in this Section of the Specifications.

3.07 TRAINING

A. Provide training sessions for OWNER's personnel for three (3) FULL normal workdays at the job-site location and/or at a location determined by the OWNER. If training is conducted in less than the time required by these specifications, the remaining time shall be utilized at the discretion of the OWNER.

B. The training session shall be conducted by the DCISS non-sales-type technical representative, who performed the field installation and start-up/setting/adjustment services.

C. At minimum, the training session shall include:

1. Operation and maintenance procedure for the equipment and all components installed.

2. Factory contact persons phone numbers, persons names, ordering procedures and procedures to follow to obtain meaningful results from the factory.

3.08 MEASUREMENT AND PAYMENT

A. No separate measurement or payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

END OF SECTION

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SECTION 16150

RACEWAYS, FITTINGS, AND SUPPORTS

PART 1 - GENERAL

1.01 DESCRIPTION AND SCOPE OF WORK

A. This section specifies raceways, fittings, and supports for all cables, conductors and electrical equipment. The Contractor shall furnish and install complete raceway systems in accordance with the following specifications.

1.02 REFERENCES

A. This section contains references to codes and standards. They are a part of this section as specified. In case of conflict between the requirements of this section and the listed standards, the requirements of this section shall prevail. All raceways, fittings and supports are to be U.L. listed and certified and shall conform to ANSI and NEMA standards.

Code	Title
NFPA 70-2014	National Electrical Code (NEC)
NEMA 250-85	Enclosures for Electrical Equipment (1,000 volts maximum)
ANSI C80.5	Rigid Aluminum Conduit and Rigid Galvanized Steel Conduit.
ANSI/UL 360	Liquidtight Flexible Steel Conduit
ANSI/NEMA FB1	Fittings and Supports for Conduit and Cable Assemblies
NEMA TC-2	Polyvinyl Chloride (PVC) Tubing and Conduit
NEMA TC-3	Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing

1.03 SUBMITTALS

A. The Contractor shall submit manufacturer's catalog data for all material provided under this section and in accordance with the requirements of Section 01300 and 01730 of the Specifications.

1. Submit certified notification from the Manufacturer that the rigid aluminum conduit system and all related materials, as described within this specification, is 99.0 percent copper-free.

2. Submit certifications of training associated with proper installation the PVC coated rigid galvanized conduit.

3. Submit certifications of training associated with proper installation of the RTRC conduit.

4. Material Safety Data sheets for all sealants, solvents, etc.

B. For each duct bank segment to be installed/renovated for the project, the schedule of values, refer to specification section 01025, shall provide the linear footage of each duct bank segment and at least the minimum following break down with cost for each duct bank segment:

a. Excavation

b. Duct bank concrete

c. Backfill

d. Duct bank materials less concrete

e. Wire/Cable

f. Plaques (if provided)

PART 2 - PRODUCT

2.01 EXPOSED CONDUIT SYSTEM INDOOR, AND EXPOSED-OUTDOOR ABOVE GROUND LEVEL

A. General: All components shall be 99.0 percent copper free aluminum

B. Rigid Metal Conduit System:

1. Conduit run above ground shall be rigid aluminum in all areas unless specifically specified otherwise hereinafter in subsection 3.02, this Section of the Specifications.

2. Rigid Aluminum Conduit shall meet the following requirements:

a. U.L. listed.

b. Comply with ANSI C80.5 and U.L.6.

3. Bending Requirements: Furnish 90-degree, 45-degree, and 30-degree factory bends. All bends of conduit sizes equal to or greater than 3½-inches in diameter shall have a minimum bending radius of 48-inches, unless otherwise noted on the PLANS. Bends of conduit sizes less than 3½-inches in diameter, shall be per manufacturers standard, unless otherwise noted on the PLANS.

4. Minimum conduit size for all work shall be 3/4 inches.

5. Manufacturer: VAW of America Inc., Allied Tube & Conduit Corp., or approved equal.

C. Conduit Hubs:

1. Provide grounding type with integral threaded insulated throat, and with solderless grounding lugs, complete with rubber gasket.

2. Manufacturer: "Myers", or approved equal

D. Grounding Bushings

1. Provide with integral insulated throat, and with solderless grounding lugs.

2. Manufacturer: "O.Z. Gedney" type ABLG with specified options, or approved equal.

E. Conduit Bodies

1. Conduit body covers shall be of the bolt-on type and shall have Type 316-Stainless Steel screws/hardware.

a. Conduit body covers shall be furnished complete with an integral neoprene gasket.

2. Manufacturer: **"**Crouse-Hinds" Form-7, or approved equal.

F. Mogul Type Conduit Bodies

1. Provide Mogul type Conduit Bodies where shown on the PLANS.

2. Conduit body covers shall be of the bolt-on type and shall have Type 316-Stainless Steel screws/hardware.

a. Conduit body covers shall be furnished complete with an integral neoprene gasket.

3. Manufacturer: **"**Crouse-Hinds" Series BUB, O-Z Gedney Series UB6X, or approved equal.

G. Conduit Unions:

1. Threaded as manufactured by “Crouse-Hinds” type UNF or UNY, or approved equal.

H. Conduit Reducers

1. Threaded.

2. Shall be used for final conduit system connection to equipment where shown on the PLANS.

3. Manufacturer: “Crouse-Hinds” type RE and type REA, or approved equal.

I. Sealing Fittings:

1. Furnish with drain

2. Manufacturer: Crouse Hinds, Type EYD, or approved equal

3. Sealing Compound:

a. Where conduit seals are installed in compliance with NEC Class-I and Class-II requirements, the sealing compound shall be as manufactured by “Crouse-Hinds” type Chico-AP, or approved equal.

b. Where conduit seals are not required for NEC Class-I and Class-II installations but are shown to be installed on the PLANS to block the migration of corrosive gases into the conduit system and conduit bodies, the conduit seals Sealing Compound shall be Scotchcast Reenterable Electrical Insulating Resin 2123 as manufactured by “3M”, or approved equal.

c. Coordinate application with the Owner.

d. For vertical seals use mineral wool packing material to form a dam in the annular space around the conductors and hold the sealing compound in place while it cures. Packing material shall be as manufactured by “Crouse-Hinds” type Chico-X, or approved equal.

J. Expansion Fittings:

1. Furnished with oversized sleeve and insulated bushing

2. Furnished with tinned copper braided bonding jumper

3. Manufacturer: O.Z./Gedney Type EXPB-A, or approved equal

K. Cord and Cable Fittings

1. Provide threaded gland nut, straight threaded body, and also a neoprene sealing cable bushing.

2. Furnished with a Type 316 Stainless Steel wire mesh grip.

3. Shall be used only where specifically shown on the PLANS.

4. Manufacturer: “Crouse-Hinds” type CGB, complete with all specified accessories, or approved equal.

L. Miscellaneous Requirements:

1. Conduit nipples shall have two independent sets of threads.

2.02 UNDERGROUND CONDUIT IN DUCT BANK SYSTEM

A. General:

1. Type: All components shall be non-metallic, except where noted herein and specifically shown otherwise on the PLANS. Refer to the PLANS.

2. Bending Requirements: Furnish 90-degree, 45-degree, and 30-degree factory bends. All bends of conduit sizes equal to or greater than 4-inches in diameter shall have a minimum bending radius of 48-inches, unless otherwise noted on the PLANS. Bends of conduit sizes less than 4-inches in diameter, shall be per manufacturers standard, unless otherwise noted on the PLANS.

3. Minimum conduit size for all work shall be 1 inch.

4. Please note the duct bank cross sectional dimensions shown on the profile drawings are approximate. Please refer to electrical details for required duct bank cross section dimensions.

B. Rigid Nonmetallic Conduit System:

1. All components shall be schedule 40 PVC, heavy wall, U.L. rated, No. 651, conforming to NEMA standard TC-2-75 and listed in conformity with Article 352 of the latest edition of the National Electrical Code (NEC).

2. All Conduit Bodies, Couplings, Adapters and Fittings shall be of the same type PVC (e.g. schedule 40 or schedule 80) as the conduit system of which they are an integral part.

3. Solvent weld: Shall be a type approved by the conduit manufacturer.

4. Manufacturer: Conduit shall be as manufactured by “Prime Conduit”, or approved equal.

C. PVC Coated Rigid Galvanized Steel Conduit System:

1. Material: Steel per UL 6 and ANSI C80.1, hot-dipped galvanized inside and out after the threads are cut.

2. Exterior Coatings:

a. After galvanizing, the conduit/fittings shall be uniformly and consistently coated with a gray PVC coating of minimal 40 mil thickness. Exception: The threads shall be coated with urethane in lieu of PVC.

b. The PVC coating adhesion performance shall be ETL verified to the Intertek ETL SEMKO, High Temperature H_2O PVC Coating Adhesion, Test Procedure for 200 hours.

3. Interior Coating:

a. After galvanizing, the interior of conduit and fittings shall be uniformly and consistently coated with a urethane coating of nominal 2 mil thickness.

4. Accessories: Threads shall be furnished with plastic thread protector caps.

5. Manufacturer: Robroy Industries, Perma-Cote, Plasti-Bond REDH_2OT, or approved equal.

D. Reinforced Thermosetting Resin Conduit (RTRC) Conduit System:

1. General:

a. May be used only where specifically permitted by subsection 3.02.C.8, this Section of the Specifications.

b. Shall comply with NEC Article 355.

2. Material:

a. Fiberglass, Reinforced Thermosetting Resin Conduit. 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. Conduit shall be low-halogen per UL 2515.

b. Manufactured using the single circuit filament winding process. Oven cured. Nominal winding angle of 54.75 degrees.

c. Carbon black shall be used as ultra violet inhibitor.

d. Internal walls shall be smooth with all fibers embedded in epoxy.

3. Certifications: NEMA TC14, UL 2420 and 2515.

4. Suitable for installation exposed outdoors and encased in concrete

5. Fittings:

a. The following fittings shall be provided. Example part numbers shown hereinafter apply to the raceway system manufacturer specified hereinafter. All part numbers required for this project are not shown. Contractor to coordinate necessary part numbers with the manufacturer for a complete installation.

b. 90 degree bends with factory installed 2 deep socket PVC coupling and 1 fiberglass coupling bonded to elbow:

1) For conduit sized 1" – 1 ½", provide type IPS. Example part number for 1": 10C-XW-90-2DF

2) For conduit sized 2" – 6", use type ID. Example part number for 2": 20D-XW-90-2DF

c. Sleeve couplings:

1) For conduit sized 1" – 1 ½", use type IPS. Example part number for 1": 10C-XW-42

2) For conduit sized 2" – 6", use type ID. Example part number for 2": 20D-XW-42

d. Female Terminal Adapters:

1) For conduit sized 1" – 1 ½", use type IPS. Example part number for 1": 10C-XW-32

2) For conduit sized 2" – 6", use type ID. Example part number for 2": 20D-XW-32

e. Straight Socket Conduit:

1) For conduit sized 1" – 1 ½", use type IPS. Example part number for 1": 10C-XW-10S

2) For conduit sized 2" – 6", use type ID. Example part number for 2": 20D-XW-20-S

6. Mix Epoxy Adhesive:

a. For ambient temperatures 40 - 70 degree F, provide type CM-2040-SFG.

b. For ambient temperatures 70 degree F and above, provide type CM-2070-SFG.

7. Mix Epoxy Adhesive Mixing Tip and Gun:

a. Mixing Tip: CM-MT

b. Mixing Gun: CM-AG

8. Accessories: Provide with adhesive couplings, spigots, adapters, and other adhesive fittings as required to connect to the other specified raceways as shown on the PLANS.

9. Manufacturer: Champion Fiberglass "Haz Duct XW", no equal.

2.03 LIQUID TIGHT FLEXIBLE CONDUIT

A. Sizes Greater than or equal to ¾ inch (in general or ½-inch when permitted) and smaller than or equal to 2 inch Flexible Conduit:

1. Conduit Type: Non-metallic type liquid tight conduit, formed from PVC plastic.

2. Conduit Installation Temperature Range: –20 degrees Celsius to + 60 degrees Celsius (suitable for use outdoors and indoors).

3. Conduit Manufacturer: ELECTRI-FLEX series NM type B-PVC, or approved equal.

B. Sizes Greater than 2 inch Flexible Conduit:

1. Conduit Type: PVC-COATED metallic liquid tight conduit, formed from PVC plastic.

2. Conduit Installation Temperature Range: –20 degrees Celsius to + 60 degrees Celsius (suitable for use outdoors and indoors).

3. Conduit Manufacturer: SEALTITE, or approved equal.

C. Fittings:

1. Fittings Type: 99.0 percent Copper-Free-Aluminum

2. Fittings Manufacturer: Appleton, Crouse-Hinds, or approved equal.

D. Liquid tight flexible conduit shall be used for connections to motors, field instruments, etc., and any equipment subject to vibration, and where shown on the PLANS. Length of conduit shall not exceed 36-inches, unless specifically noted otherwise on the PLANS.

E. Minimum liquid-tight flexible conduit size for all work shall be ¾-inch unless specifically noted otherwise on the PLANS.

1. Exception: Where field instrument enclosures are fitted with ½-inch NPT threaded conduit hub(s), ½-inch liquid-tight flexible conduit shall be permitted for the final conduit connection to the instrument with prior Owner approval.

a. Transition to ½-inch liquid-tight flexible conduit shall be implemented by installing a pull box or conduit body and conduit reducer at the point of transition.

2.04 MISCELLANEOUS

A. Polyurethane foam duct sealant: FST-250 and FST-MINI Duct Sealant as manufactured by "Polywater", or approved equal

B. Pipe Tape: Pipe tape shall be 20 mil, polyvinyl chloride based tape, having dielectric breakdown voltage rating of 20,000 volts and normal service temperature range of -55°F to 175°F. Pipe tape shall be manufactured by 3M Company No.51, or approved equal.

C. Conduit Sleeves: Conduit sleeves shall be schedule 80 PVC, heavy wall, U.L. rated, No. 651, conforming to NEMA standard TC-2-75 and listed in conformity with Article 347 of the National Electrical Code (NEC). Also refer to the conduit penetration details shown on the PLANS.

D. Conduit Hole Seals: Hole seals shall be stainless steel, U.L. listed as NEMA 4X oil-tight, complete with oil-resistant gasketing, backplate, stud and wing nut. Hole seals shall be manufactured by Hoffman, Rittal, Cooper B-Line, or approved equal.

E. Mastic material shall be Bitumastic 50 as manufactured by Carboline.

2.05 ELECTRICAL EQUIPMENT AND RACEWAY SYSTEM SUPPORT CHANNELS

A. General requirements for all support channels:

1. Channels located in all areas:

   a. Type: 316-Stainless Steel.

   b. Manufacturer: "Unistrut Corporation", or approved equal.

B. All fastening hardware, fittings, supports, post bases, conduit clamps, beam clamps channel nuts, threaded rod, framing system, etc. shall be as follows:

1. Items located in all areas:

   a. Type 316 stainless steel

2. Manufacturer: "Unistrut Corporation", or approved equal.

3. Additionally, the following designations correspond to the following "Unistrut Corporation" series numbers as used in the details shown on the PLANS:

   a. Items located in all areas:

      1) Beam clamps: "Unistrut Corporation" series P-2785ST and P-2786ST, or approved equal.

      2) Swivel fittings: "Unistrut Corporation" series M-2137ST, or approved equal.

      3) Post bases: "Unistrut Corporation" series P-2072AST and series P-2073AST, or approved equal.

4) Hanger clevis fittings: “Unistrut Corporation” series P-2682ST, or approved equal.

C. For conduits mounted on roof, do NOT penetrate the roof in any way for the mounting of equipment on the roof. For mounting of conduit on roof, furnish and install Unistrut UNIPIER ROOFTOP PIPE SUPPORT SYSTEM, elevated support with stainless steel base.

D. Mechanical expansion anchors shall be fabricated with Type 316-Stainless Steel and shall be installed per the manufacturer’s recommendations.

2.06 MANHOLES AND HANDHOLES

A. Furnish and install handholes/manholes as shown on the PLANS and as specified herein. Also, refer to the Civil/Structural Specifications and PLANS for additional requirements.

B. Provide all cable pulling eyes, cable support system components and accessories indicated on the PLANS and as otherwise required. Arrange support systems so that each cable can be securely anchored.

C. All handholes/manholes shall have the following additional features:

1. Type: Cast-in-place reinforced concrete

   a. Comply with the requirements of Division 3 of the Technical Specifications and of the PLANS.

2. Lid: Heavy traffic rated ductile iron

   a. Comply with ASTM A536.

   b. Round with a minimum diameter of 48 inches, unless shown otherwise on the PLANS.

   c. Tagged as ELECTRIC and as follows:

      1) Cast directly into the lid during the lid manufacturing process by the lid manufacturer

      2) Minimum of 2-inch high alphanumeric characters.

3. Interior Dimensions: At minimum as shown on the handhole/manhole PLANS.

4. Neck: Furnish length of neck as required to connect the handhole/manhole chamber with the handhole/manhole lid.

5. Duct Bank Entry Window: At minimum as shown on the handhole/manhole PLANS.

6. Cable Pulling Eyes: Furnish one cable pulling eye for each duct bank penetration into the manhole and as follows:

a. Located on structural wall opposite each duct bank penetration into the handhole/manhole and having vertical elevation and horizontal alignment to accommodate cable pulling and minimize cable pulling tension.

b. Pulling eyes may not be shown on the handhole/manhole PLANS; however, they are to be installed per the requirements of this specification.

2.07 CABLE SUPPORT SYSTEM IN UNDERGROUND ELECTRICAL MANHOLES AND HANDHOLES

A. General Requirements for support channels:

1. Type: Type 316-Stainless Steel

2. Manufacturer: "Unistrut Corporation" series P-1000ST and P-1001ST, or approved equal.

B. All fastening hardware, fittings, supports, post bases, conduit clamps, beam clamps channel nuts, threaded rod, framing system, etc. shall be fabricated with Type 316 stainless steel, as manufactured by "Unistrut Corporation", or approved equal. Additionally, the following designations correspond to the following "Unistrut Corporation" series numbers as used in the details shown on the PLANS:

1. Porcelain Clamps and Saddles-"Unistrut Corporation P1787A through P1795B Porcelain Cable Clamps", for both Electric and Communications and Instrumentation and Control.

2. Surface Mounted Vertical Channels (Columns)-"Unistrut P-1000ST Type 316 stainless steel channels and accompanying Unistrut post bases".

3. Surface Mounted Horizontal Channels (side mounted channels)-**"**Unistrut P-1001ST Type 316 stainless steel channels and accompanying Unistrut post bases as well as wall mounted vertical channels".

4. Brackets-**"**Unistrut" P-2515 ST of 15 inch length for Electric, and P-2542 ST of 15 inch length for Telephone and Communications. All parts given shall be Type 316 stainless steel.

5. Beam Clamps – "Unistrut" P-2785 ST". All parts given shall be Type 316 stainless steel.

2.08 UNDERGROUND ELECTRICAL SYSTEM SIGNAGE

A. Manhole and Handhole Identification Plaques:

1. Furnish and install an identification Plaque for each manhole and handhole <u>installed under this project</u>.

a. Each plaque shall be manufactured of reinforced concrete.

1) Concrete shall be Class ‘A’ per Section 403S “Concrete for Structures”.

2) A red admixture shall be added to the concrete.

a) Admixture Ratio: 5 pounds of admixture per 94 pound sack of cement or 16 pounds of admixture per cubic yard of concrete.

b) Admixture Manufacturer: ChemSystems, Inc. series HBS #120 Conduit Red, or approved equal.

b. Plaque location: Securely install each plaque at ground level directly adjacent to and, outside the perimeter of the housekeeping pad cover, of its respective manhole/handhole.

2. Recess mount (flush mount) each concrete plaque in a field fabricated “Plaque Frame Assembly”.

a. Plaque Frame Assembly Construction: Fabricated of reinforced concrete, which shall also be constructed per the requirements of the “Outdoor Electrical Equipment Pad/Concrete Slab Detail” shown on the PLANS.

b. Plaque Frame Assembly Size: The width and length of the “Plaque Frame Assembly” shall at least be equal to twice the width and length dimensions of the associated plaque, but not less than 24-inches Wide and 24-inches Long.

3. The plaque shall be equipped with holes and/or other means for securely fastening/tying the plaque into the “Plaque Frame Assembly”.

4. The text and/or objects/content shall be Engraved on the plaque. The exact arrangement/layout/font style of the text/objects/content and presentation format of the information to be inscribed on each plaque shall be decided by AUSTIN WATER UTILITY during shop drawing submittal process (submit a drawing for each plaque as part of the shop drawing review packages). As minimum, the identification plaque of each manhole and handhole shall include the following information inscribed on it:

a. Manhole/handhole identification name, in full.

1) Minimum lettering size shall be 1-inch in height.

b. Identification name of each duct bank entering/exiting the manhole/handhole, side/point in which duct bank enters/exits the wall of the manhole/handhole, with an ARROW the direction of duct bank routing within the first 50-feet from the manhole/handhole.

1) Minimum lettering size shall be ½-inch in height.

c. Inner dimensions of the manhole/handhole (width, length and height of the chamber area).

1) Minimum lettering size shall be ½-inch in height.

d. Invert elevation of the finished floor of the manhole/handhole.

1) Furnish the services of an on-site field surveyor to obtain this data during the installation of the manholes/handholes and prior to the installation of the identification plaque.

2) Minimum lettering size shall be ½-inch in height.

e. A conceptual plan view drawing (outline type) of the manhole/handhole.

f. Voltage class of conductors entering/existing the manhole/handhole.

1) Minimum lettering size shall be ½-inch in height.

B. Duct Bank System Identification Plaques:

1. Furnish and install identification Plaques per each underground duct bank installed under this project.

a. Each plaque shall be manufactured of reinforced concrete.

1) Concrete shall be Class 'A' per Section 403S "Concrete for Structures".

2) A red admixture shall be added to the concrete.

a) Admixture Ratio: 5 pounds of admixture per 94 pound sack of cement or 16 pounds of admixture per cubic yard of concrete.

b) Admixture Manufacturer: ChemSystems, Inc. series HBS #120 Conduit Red, or approved equal.

b. Plaque location: Securely install each plaque at ground level and directly on top of its respective duct bank run.

2. Recess mount (flush mount) each plaque in a field fabricated "Plaque Frame Assembly".

a. Plaque Frame Assembly Construction: Fabricated of reinforced concrete, which shall also be constructed per the requirements of the "Outdoor Electrical Equipment Pad/Concrete Slab Detail" shown on the PLANS.

b. Plaque Frame Assembly Size: The width and length of the "Plaque Frame Assembly" shall at least be equal to twice the width and length dimensions of the associated plaque, but not less than 24-inches Wide and 24-inches Long.

3. Each plaque shall be equipped with holes and/or other means for securely fastening/tying the plaque into the concrete housekeeping pad.

4. Position each plaque at ground level where the center-line of the plaque is the same as the center-line of the width of the respective duct bank.

5. Where a plaque has to be located within an access roadway, then the plaque assembly (housekeeping pad and plaque) shall be flush with the finished surface of the roadway.

6. Where a plaque has to be located directly on grade, then the finished surface of the plaque assembly (housekeeping pad and plaque) shall be positioned to be at 1-inch above finished grade level.

7. The text and/or objects/content shall be Engraved on the plaque. The exact arrangement/layout/font style of the text/objects/content and presentation format of the information to be inscribed on each plaque shall be decided by AUSTIN WATER UTILITY during shop drawing submittal process (submit a drawing for each plaque as part of the shop drawing review packages). As minimum, the identification plaque of each duct bank shall include the following information inscribed on it:

   a. Duct bank identification name, in full. The name shall be preceded by an ARROW and followed by an ARROW. Arrows shall indicate the BIDIRECTIONAL PATH of the duct bank (when viewed at point of the plaque).

      1) Minimum lettering size shall be 1-inch in height.

   b. Dimensions of the duct bank. Indicate width and height of the duct bank in INCHES (include concrete envelope around the duct bank). Indicate length of the duct bank in FEET, for the particular run identified by the associated plaque.

      1) Minimum lettering size shall be ½-inch in height.

   c. Invert elevation of the duct bank when measured from finished grade (at the location of the associated plaque) to the bottom of the lowest row of conduits in the associated duct bank (at the location of the associated plaque).

      1) Furnish the services of an on-site field surveyor to obtain this data during the installation of the duct bank system.

      2) Minimum lettering size shall be ½-inch in height.

   d. Quantity and size of the conduits housed by the associated duct bank.

      1) Minimum lettering size shall be ½-inch in height.

   e. Voltage class of conductors routed through the conduits within the associated duct bank.

      1) Minimum lettering size shall be ½-inch in height.

8. Place the required number of the duct bank identification plaques per each STRETCH of an underground duct bank. A STRETCH of duct bank is a run of a given duct bank from one point to another; i.e., from one manhole (or handhole) to another, from an electrical closet to a manhole, from an electrical equipment (switchgear, transformers, motor control centers, instrument and control cabinet, etc.) to another, from an electrical equipment (switchgear, instrument and control cabinet, etc.) to a manhole/handhole/pull box, etc.; from one pull and/or junction box to another, etc.

9. Place as many plaques as required within each STRETCH of a duct bank to clearly identify and follow the direction, path, routing, depth, etc. of each STRETCH of a duct

bank as well as all duct banks installed under this project. As minimum, per each stretch of a duct bank, place identification plaques at the following intervals/locations:

a. At 12-feet distance from electrical closets and/or vaults or other point of entry/exit to/from buildings, and

b. One per a maximum linear distance (straight line) of 200-feet interval of duct bank stretch, and

c. At point of every turn in direction even when a turn is as minimal as 10-degrees, and

d. At point of split [Y-INTERSECTION] prior to reaching any destination (destination = electrical equipment, manhole, handhole, closet, vault, pull box, junction box, etc.)., and

e. At 12-feet distance from Manholes and Handholes.

10. Final locations of all duct bank identification plaques shall be coordinated with the Owner.

PART 3 - EXECUTION

3.01 GENERAL

A. Install electrical equipment and conduit raceway system in accordance with the recommendations of the manufacturer, the requirements of the latest edition of the National Electrical Code, and the PLANS. All cables/wiring shall be installed in a raceway system.

B. Contractor shall be trained and certified by the PVC coated rigid galvanized steel conduit manufacturer in the proper installation of the PVC coated rigid galvanized conduit.

C. Contractor shall be trained and certified by the Fiberglass conduit manufacturer in the proper installation of the Fiberglass conduit.

3.02 CONDUIT SYSTEM

A. General:

1. Run conduits continuous from outlet to outlet, from outlets to cabinets, pull or junction boxes, etc.

2. Install all conduits as a complete system before wiring is pulled in. Conduits shall be reamed, thoroughly cleaned of debris, and swabbed immediately before wire is pulled.

3. Furnish and install an expansion fitting for each conduit across structural expansion joints. Coordinate locations of expansion joints with the PLANS. Conduit expansion fittings shall be constructed of material equivalent to the conduit system in which they

are installed. Additionally, furnish and install additional appropriate fittings such as conduit unions, adapters, etc. as required for a complete installation.

4. Conduit shall contain no more than the equivalent of three (3) 90 degree bends between outlets or pull points.

5. Maintain a minimum 6 inch clearance between conduit and piping and a minimum 12 inch clearance between conduit and heat sources.

6. Protect all coated conduit from accidental coating damage during storage and installation. Repair all damaged conduits in accordance with manufacturer's recommendations at no additional cost to the OWNER.

7. Furnish and install temporary conduit closures during construction activities to prevent foreign matter from entering raceways.

8. Install conduit measuring tape in all unused conduits shown on the PLANS as empty or spare. Conduit measuring tape shall have measurements in feet and shall be constructed of durable Kevlar material having low stretch (expansion) rate as manufactured by Ideal Industries Incorporated, or approved equal.

9. Prior to the installation of wiring in the OWNER's existing conduits, thoroughly clear existing conduits that shall be used for renovation activity to remove 100 percent of obstructions (objects, rocks, concrete bits, rough edges, debris, etc.) that may damage the proposed wiring during the wire installation process. Field verify that the proposed wiring can be installed.

B. Exposed Conduit System Indoor, and Exposed-Outdoor Above Ground Level:

1. Rigid conduit joints shall be cut square, threaded, reamed smooth and drawn up tight. Make field bends or offsets with an approved bender or hickey or hub type conduit fittings.

2. Run conduit parallel or at right angles to building lines and such to avoid moisture traps.

3. Arrange conduits to maintain headroom and present a neat and workmanlike appearance.

4. Support conduit using support channels as shown on the PLANS and as specified herein.

5. Coat all conduit threads with Penetrox or Noalox prior to assembly.

6. For outdoor and indoor surface mounted installations, secure conduits to cabinets and boxes with gasketed conduit hubs

7. Secure conduit runs firmly to specified support channels by conduit straps or by hangers, as required, and as shown on the PLANS.

8. Conduits run above ground shall be supported at least every 10 feet and once in every change in direction and at the end of each straight run terminating in an enclosure and within three feet of every junction box.

9. Where aluminum conduit is in contact with equipment of dissimilar material (other than Stainless Steel) such as pipes, frames, structural frames, etc., isolate the aluminum conduit by wrapping the aluminum conduit with 3M company No.51, 20 mil pipe tape using a 50 percent overlap throughout the entire distance/length of the contacted region plus an additional 18-inches of distance beyond either end of the contacted region.

C. Underground Conduit in Duct Bank System:

1. Install all underground conduit in concrete encased and steel reinforced duct banks.

   a. Concrete shall be Class 'A' per Section 403S "Concrete for Structures" unless noted otherwise on the PLANS. A red admixture shall be added to the concrete at a rate of 12 pounds per cubic yard of concrete and per the requirements of Section 403S. Red admixture shall meet the requirements of ASTM C-979-82. Red admixture shall be as manufactured by ChemSystems, Inc. series HBS #120 Conduit Red, or approved equal. Also, refer to conduit/duct bank reinforcement and concrete encasement details shown on the PLANS and the Civil/Structural Specifications and PLANS for additional requirements.

   b. Reinforcing Steel shall be per Section 406S "Reinforcing Steel" unless noted otherwise on the PLANS. Also, refer to conduit/duct bank reinforcement and concrete encasement details shown on the PLANS and the Civil/Structural Specifications and PLANS for additional requirements.

   c. Install detectable underground warning tapes at 12-inches below finished grade along the entire length of each duct bank. Each tape shall be a minimum of 6-inches wide, 4 mil thick, laminated, and contain a aluminum foil core backing. The tape shall be detectable using a non- ferrous locator. The tape color shall be red and shall be labeled with the words "CAUTION BURIED ELECTRIC LINE BELOW" in black lettering. For duct banks less than 24-inches wide, install one length of tape aligned along the centerline of the duct bank. For duct banks 24-inches wide and larger, install two lengths of tape, with each length aligned with each edge of the duct bank along the width of the duct bank. Warning tape is not required along the length of the specific portion of a duct bank that is installed underneath a building concrete floor slab. Detectable underground warning tape shall be manufactured by Presco, Ideal Industries, Thomas & Betts E-Z-Code®, or approved equal. Also, refer to conduit/duct bank reinforcement and concrete encasement details shown on the PLANS.

2. Provide a minimum of 3-inches separation between conduits installed in concrete construction except at panelboards, pull or junction boxes and/or other locations where the conduits are grouped. Furnish and install plastic spacers as shown on the PLANS.

3. All underground conduit joints shall be watertight in accordance with the manufacturer's recommendations.

4. Underground electrical duct bank systems shall be installed per the PLAN and PROFILE Drawings included in the Contract Documents.

   a. Should a duct bank not be furnished with Profile Drawings, such underground system duct banks shall be installed with the minimum depths below finished grade

as shown on the PLANS and shall slope 3-inches per 100 feet from high points toward pull boxes and handholes/manholes, at minimum.

5. Underground duct bank systems shall be coordinated with the depths of Civil/Structural foundations, beams, etc. No conduit shall be routed through grade beam slab of a building floor slab.

6. Where a duct bank penetrates a concrete structure, dowel between the duct bank and the structure at the point of penetration and tie the steel reinforcing rebar system of the underground duct bank system to the concrete structure and steel reinforcing rebar system of the concrete structure. Refer to the Civil/Structural Specifications and PLANS for additional requirements.

7. Transition from underground (underground work in duct bank) to above ground conduit as shown on the PLANS.

8. Where PVC coated rigid galvanized steel conduit is shown on the PLANS, Contractor may employ RTRC conduit in lieu of the PVC coated rigid galvanized steel conduit.

9. Where factory bends/elbows (11-1/4°, 22-1/2°, 30°, 45°, and 90°), as specified in Part 2.02 A 2 of this Specification, are not manufactured and field bends become necessary, field bends may be performed using a heat box type electric PVC conduit heater. The use of open flame to heat the PVC conduit is NOT permitted. Utilize a PVC conduit plug set to plug the ends of the conduit throughout the heating process and trap the air inside the conduit to help keep the PVC conduit from collapsing while forming the bend.

D. Conduit Penetrations:

1. Install sleeves for conduit penetrations of walls and floors unless shown otherwise on the PLANS. Install sleeves during erection of concrete and masonry walls. Exception: Sleeves are not required for conduits stub-ups through floor slab from underground duct bank or for conduits installed through penetrations cored in solid walls and floors.

2. Where aluminum conduit penetrates a wall/floor-slab and/or walls/floors of dissimilar material (other than Stainless Steel) or is in contact with dissimilar material, wrap the aluminum conduit with Pipe Tape using a 50 percent overlap throughout the entire distance/length of the penetration and an additional 6-inches of distance beyond either side of the penetration/contacted region.

3. Install pitch pans on conduits which penetrate through roofs.

4. Also refer to the conduit penetration details shown on the PLANS.

E. Miscellaneous:

1. Seal empty spare conduits (at above ground stub-ups) with threaded insert plugs sized to the trade size of the conduits.

   a. Threaded insert plug shall have a square head and shall be constructed from copper-free Aluminum material.

b. Threaded insert plug shall be Type CUPX by Hubbell-Killark, Type PLG by Crouse-Hinds, or approved equal.

2. Seal and pack/fill ends of each conduit with polyurethane foam duct sealant. Foam shall be fire rated and shall be UL recognized for fire retardant rating and use for electrical raceway systems as well as compliant with NEC requirements for raceway seals and NEC requirements for minimizing gas and vapor passage for boundary seals for Class 1, Div 2.

3. In all sealing fittings, utilize sealing compound to seal around and between each conductor and associated sealing fitting body.

4. Each conduit Bell-End fitting shall have integral concentric water stop ring surrounding the exterior of the Bell-End.

5. Seal empty underground conduit Bell-Ends. Furnish and install conduit manufacturer's conduit Plug with Pull Tabs to seal each empty underground conduit at each Bell-End for all duct banks renovated in this project. Conduit Plug shall be of Polyethylene material.

F. Requirements for cables inside of Manholes, Handholes, etc.:

1. Arrange cables so that there is a minimum of crossing. Provide slack in each cable.

2. Secure cables in handholes/manholes on support channel system as specified herein and as shown on the PLANS.

G. Connections to Equipment:

1. Liquid tight flexible conduit shall be used for connections to motors, field instruments, etc., and any equipment subject to vibration, and where shown on the PLANS. Length of conduit shall not exceed 36-inches, unless specifically noted otherwise on the PLANS.

3.03 INSTALLATION OF SUPPORT CHANNELS

A. Utilize support channels and mounting hardware as previously specified to install raceways, and any other surface mounted electrical, instrumentation and control equipment. Refer to details shown on the PLANS. Use 316 stainless steel split ring lock washers with mounting hardware when installing support channels.

B. Whenever support channels are cut in the field, the cut ends shall be filed smooth and shall be cleaned using liberal amounts of a contact cleaner to remove all residual elements from the cutting and filing process. Coat all field cut ends with cold galvanizing paint.

3.04 HOUSEKEEPING CONCRETE PAD FOR EQUIPMENT

A. Provide housekeeping concrete pad for all outdoor equipment whether it is free-standing or surface mounted. All housekeeping pad edges shall be chamfered. Outdoor electrical equipment pads shall be as detailed on the PLANS.

B. Provide housekeeping concrete pad for all indoor free-standing equipment. Indoor electrical equipment pads shall be as detailed on the PLANS.

3.05 MEASUREMENT AND PAYMENT

A. No separate measurement or payment for work performed under this Section. All costs are included in the Base Bid.

END OF SECTION

SECTION 16182

MEDIUM VOLTAGE CABLES

PART 1 - GENERAL

1.01 SCOPE

A. Furnish and install all medium voltage cables (5kV and 15kV) required for this project. Comply with the requirements of the contract documents, as applicable.

B. PLANS indicate the size and quantity of cable required.

1.02 QUALITY ASSURANCE

A. Manufacturer: Furnish cable meeting these Specifications and manufactured by CME Wire, Kerite Company, Okonite Company, Inc., CABLEC Corporation, Perelli Cable Corp, or approved equal meeting all the special requirements of this specification.

B. Standards: Meet applicable requirements of NEC, OSHA, IPCEA, U.L. and IEEE. U.L. listed Type TC for use in cable trays and underground electrical duct bank systems.

C. Factory and On-Site (Field) Tests: Factory test cables in accordance with applicable UL, NEMA, ICEA and AEIC standards. Field test all cables by an independent testing company as indicated elsewhere in the Section of the Specifications. Furnish certified copies of both Factory and Field (On-Site) test reports. Format and quantity of the reports shall be per the requirements of Sections 01300 and 01730 of the Contract Specifications.

1.03 SUBMITTALS

A. Submit shop drawings in accordance with Section 01300 of the Contract Specifications. Additionally, at minimum, submit the following information and materials:

1. Cable material sample (minimum 12 inches long).

2. Catalog data for Cable, Stress Cone and Elbow Termination Kits, Splice Kits, and Wire Pulling Lubricant.

   a. Submit notification of approval issued by the Cable Manufacturer that indicates acceptance and approval of the use of the selected stress cones, elbows, splices, and wire pulling lubricant. NOTE: Proposed stress cones, elbows, splices, and pulling lubricant <u>shall not be accepted</u> without this notification.

3. HIPOT and Megger Test procedures, test results forms, manufacturer's recommended test voltages, and manufacturer's cable maintenance and periodic testing recommendations.

4. HIPOT and Megger Test results and testing instrument calibration certification. NOTE: Cables shall not be field tested without an approved cable test procedure and test results forms.

5. Pulling tension and sidewall pressure calculations.

6. A list of cable tags, showing the identity of each cable, the content of the tag, the initially suggested height and type of lettering, mounting/installation method, and the tag material and type and size (dimensions).

B. Submit Operations and Maintenance Manuals (O&M) which shall include bound hard-copies and electronic copies of the approved shop drawings, factory test and certification reports, and on-site/field test and certification reports.

1.04 PRODUCT PROTECTION

A. Deliver and store on appropriately sized cable reels. Do not allow flange to bump cables on adjacent reels.

B. Check for indication of any damage to the reels. Do not drop reels from any height.

C. Store cable on a solid, well drained location. Cover cable reels with plastic sheeting or tarpaulin.

D. Seal cable ends with heat shrinkable end caps. Do not remove end caps until cables are ready to be terminated.

1.05 SHIPMENT

Cable shall be shipped directly from the cable manufacturer facility to the project site. Ship cable in continuous lengths. Cable ends are to be completely sealed against moisture and contaminants. The cable on the reel is to be protected with plyboard or tekboard lagging held securely in place with steel banding.

PART 2 - PRODUCTS

2.01 GENERAL

A. For 5kV cable installations, furnish single-conductor cable assemblies suitable for use in circuits not exceeding 5,000 volts measured phase-to-phase at conductor temperatures of 90 deg. C continuous normal operation, 130 deg. C for emergency overload conditions, and 250 deg. C for short circuit conditions, in wet or dry locations.

B. For 15kV cable installations, furnish single-conductor cable assemblies suitable for use in circuits not exceeding 15,000 volts measured phase-to-phase at conductor temperatures of 90 deg. C continuous normal operation, 130 deg. C for emergency overload conditions, and 250 deg. C for short circuit conditions, in wet or dry locations.

C. The manufacturer's name, the voltage class, type of insulation, thickness of insulation, conductor size, U.L. listing and date of manufacture shall be printed on the jacket.

D. Cables shall be suitable for use in partially submerged wet locations, in non-metallic or metallic conduits, underground duct systems and direct buried installation.

2.02 MATERIALS

A. General: Comply with ICEA S-93-639, AEIC CS8 and UL 1072.

B. Phase Conductors: Copper, stranded in accordance with ASTM B-496. Tinned in accordance with ASTM B-33.

C. Phase Conductors Strand Screen: Extruded semiconducting copolymer Strand Screen compatible with EPR. Concentrically extruded directly over the copper strands. Minimum average thickness of 40 mils with a minimum thickness of 35 mils and maximum thickness of 45 mils. Strand Screen shall meet the electrical and physical requirements of ICEA S-68-516, AEIC CS6 and UL 1072.

D. Phase Conductor Insulation: A homogenous wall of thermosetting Ethylene-Propylene Rubber (EPR) based elastomer applied directly over the Phase Conductor Strand Screen. Average thickness of 135 mils. Physical and electrical properties per IPCEA Paragraph 3.7. Test for voids and contaminants per AEIC 6-75, Section A-3.

E. Phase Conductor Insulation Screen: Extruded semiconducting copolymer Strand Screen compatible with EPR and providing 100% coverage directly over the Conductor Insulation. Minimum average thickness of 40 mils with a minimum thickness of 35 mils and maximum thickness of 45 mils. Strand Screen shall meet the electrical and physical requirements of ICEA S-68-516, AEIC CS6 and UL 1072.

F. Phase Conductor Shielding: Conductor shielding shall be concentrically extruded directly over the Conductor Insulation Screen. Apply a semi-conducting tape, providing 100% coverage directly over the insulation with 10% lap. Apply (helically) a 5 mil copper tape shield directly over the semiconducting tape (Conductor Insulation Screen) with a 20% lap over the auxiliary tape shield. Wire shielding to meet IPCEA Paragraph 4.1.1.3.

G. Manufacturer's Cable Overall Jacket: Overall cable jacket shall be Flame resistant and shall be PVC jacket encasing the cables round core.

H. Identification: Surface printed on overall jacket identifying manufacturer, insulation type, jacket type, conductor size, UL symbol and voltage.

I. Stress Cones and Splice Kits: Use Stress Cones as manufactured by 3M or approved equal, and splice kits of Model HVS as manufactured by Raychem, or approved equal, and as also recommended by the Medium Voltage Cable Manufacturer. A letter of approval must be

issued by the Cable Manufacturer which shall accept and approve the use of the selected Stress Cones and Splice Kits. Stress cones located outdoors shall have skirts and shall be UV resistant.

J. Deadbreak Elbows: Provide Deadbreak Elbows with integral test point as manufactured by Elastimold (Thomas and Betts), or approved equal, and as also recommended by the Medium Voltage Cable Manufacturer. A letter of approval must be issued by the Cable Manufacturer which shall accept and approve the use of the selected dead break elbows.

K. Cable Tags:

1. Cable tags with holders shall be Polyethylene tags.

2. Cable tags shall be installed at the following points on each cable:

   a. Origin

   b. Destination

   c. At each entry to manhole and pull box.

   d. In above ground electrical/cable closets.

3. Cable tags to indicate the following:

   a. Load (as indicated on One Line Diagram).

   b. Circuit number (as indicated on One Line Diagram).

   c. Phase.

   d. Load break switch, controller, and/or circuit breaker tag serving the cable and served by the cable.

4. Tag each cable, cable tags shall be in BLACK lettering with YELLOW background. The height of each letter shall be 1½", in the submittal review process however the Owner at his/her discretion may elect to change the lettering height of certain tags to a size smaller than 1½" or maintain the height of each letter of each tag at 1½" in height, the Contractor shall make this adjustment as deemed necessary by the Owner at no additional cost to the Owner. Cable tags shall be model TH-10 complete with slip-in characters style EZ-H and nylon tie straps as manufactured by Almetek, 1451 Route 46, Ledgewood, New Jersey or approved equal. Fasten each end of wire tag with the nylon tie straps to insure a secure installation.

5. Additionally, comply with the Austin Water Utility Tagging Methodology described in Section 16200 of the Contract Specifications, Subsection 3.03 Wiring Methodology.

L. Cable Lubricant:

1. Cable lubricant shall be manufactured specifically for lubricating cable which is pulled through conduit.

2. Cable lubricant shall be of type recommended by cable manufacturer.

2.03 FACTORY TESTS AND INSPECTION

A. Perform manufacturers standard production testing and inspection in accordance with the latest version of UL, NEMA, ICEA and AEIC standards.

B. Final test on Shipping Reel:

1. Each length of completed cable shall pass an AC voltage withstand test applied for one minute at the manufacturer's recommended test voltage for 5kV cables or for 15kV cables, as applicable for the completed installation.

2. Following the AC voltage test, the insulation resistance shall be measured and must not be less than that specified in Subsection 2.03 A above.

C. Factory Certification:

Certification shall be provided by the manufacturer that the cables similar in construction and materials have been subjected to and passed the following test.

1. U-Bend Discharge Test:

As described in IPCEA S-68-516 paragraph 6.23.3 with the energy source equal to a minimum of 200 volts/mil of insulation thickness, cable must withstand this test for a minimum of 1000 hours without failure.

2. Conductor and Shield Continuity

Each length of completed cable is to be tested for conductor and shield continuity.

D. Factory Test Reports:

Furnish in writing certified test reports for the cables furnished on this project, including Production Test results for each shipment of cable. Format and quantity of reports shall be per the requirements of Section 01300 of the Contract Specifications.

E. Factory Test Inspection:

All tests may be witnessed by a representative of Austin Water Utility. Give written notice of test at least 14 Calendar days in advance.

2.04 5KV CABLE APPLICATION

A. Cable Type: Single conductor shielded cable.

B. Insulation Level: Insulation level shall be 133 percent

C. Operating Voltage: Operating voltage level shall be 4,160 volts, 3-phase, 60Hz, grounded distribution system.

2.05 15KV CABLE APPLICATION

A. Cable Type: Single conductor shielded cable.

B. Insulation Level: Insulation level shall be 133 percent

C. Operating Voltage: Operating voltage level shall be 12,470 volts, 3-phase, 60Hz, grounded distribution system.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install cable in accordance with manufacturer's instructions and recommendations.

B. After conduit banks are completed and in place, all conduit (new and existing) shall be swab-cleaned of all dirt, foreign material, and moisture.

C. Apply lubricant to one end of the conduit, before cable installation, and wipe to the other end with a mandrel. Apply sufficient lubricant to cause lubricant to spill from the conduit as the mandrel is withdrawn. Do not use soap, detergent, etc., to lubricate.

D. Use tension meter to monitor all cable pulling tension in order to ensure manufacturer's maximum recommended tension is not exceeded.

E. Start cable pulls from end which provides least pulling resistance.

F. After pulling and until final termination, seal cable ends to prevent entrance of dirt, moisture and other foreign material.

G. Carefully and neatly lace all cable entering and leaving manholes through cable supports.

H. Tag all cables. Utilize fire retardant and corrosion resistant cable tags with minimum of 1½"-high lettering, per Subsection 2.02-I (above) of this Section of the Specifications.

I. Terminate all cable with appropriate terminator.

J. Do not bend cable to a smaller radius than recommended by IPCEA and the cable manufacturer.

K. Record reel numbers, cable description, pulling tensions and any other observations which may be useful in defining any causes of trouble in the future.

L. Install cable in lengths sufficient to avoid splices. DO NOT splice cables except where the cables are scheduled to be spliced to the existing 5kV Plant Power Distribution System. Terminate all cable with stress cones.

M. Color code all cables per City of Austin color code.

N. Train cables around the sides of the manholes to avoid manhole traffic. Do not run cables diagonally across the manhole. Tag all cables in manhole with permanent tags identifying the power source and the load served. Allow sufficient slack in each cable, at each manhole and pull-box, to make splices in the future. Fireproof all cables within manholes with approved arc and fireproofing tape capable of withstanding temperatures to 23,000 deg. F (13,000 deg. K) for 70-cycles.

O. Arrange cable support systems so that each cable can be securely anchored to prevent migration downgrade through ducts installed on steep grades.

P. Install a 600 volt type THW insulated (Green color) ground wire in each conduit run of each individual Medium Voltage (5kV or 15kV) cable carrying conduit. Do not utilize the shield of any 5kV or 15kV cable as ground and/or grounding conductor/wire. Size of the 600 volt insulated ground wire (per conduit run, and per one piece of mechanical equipment only) shall be #250 MCM (minimum) or as noted/shown on the PLANS.

Q. Support and clamp cables in manholes and above ground cable closets per details shown on the PLANS and per the requirements of Section 16150 "Raceway, Fittings and Supports" of the Specifications.

3.02 TESTING

A. Megger Test: Give each cable a full dielectric absorption test with 5,000 volt motor-driven megger. Record reading for five (5) minutes before and after the HIPOT test.

B. HIPOT Test: Test all medium voltage cable with terminators after installation in conduit but before cable is connected to any equipment. Test each cable individually. HIPOT test shall not be performed for existing medium voltage cables which are being reused in renovation activity.

C. Test voltage for 5kV and 15kV cables shall be per the manufacturer's recommendations for fifteen (15) minutes in strict accordance with manufacturer's recommendations. Take leakage current readings every fifteen (15) seconds for the first minute and at one (1) minute intervals during the remainder of the test. Cable shall not be accepted if there is a continual increase in leakage current throughout the test. Test voltage for 5kV and 15kV cables shall be performed for both proposed medium voltage cables as well as existing medium voltage cables which are being reused during any point in the construction sequence.

D. Exercise extreme care to assure a solid ground of cable sheaths and conductors not being tested.

E. Field Testing Company and Witnessing: All Field Testing is to be performed by an independent testing company normally employed in this field. Testing shall be witnessed by the Owner and the Engineer. All test reports shall be certified by the testing company. Format and quantity of reports shall be per the requirements of Sections 01300 and 01730 of the Contract Specifications.

3.03 MEASUREMENT AND PAYMENT

A. No separate measurement or payment for work performed under this Section. All costs are included in the Base Bid.

END OF SECTION

SECTION 16200

WIRING (600 VOLTS AND BELOW)

PART 1 - GENERAL

1.01 SCOPE

A. This item of the specifications describes the field wiring to be furnished and installed in the project. The PLANS designate the type, number, and size of field wiring.

B. Furnish and install all wiring required to make the electrical system completely and satisfactorily operable. Comply with the National Electrical Code and all applicable federal, state, and local codes, regulations and ordinances.

C. The requirements of this section also apply in whole to the installation of the fiber-optic cables. Fiber optic cables are specified in Section 17600 "Distributed Control System" of the Specifications.

D. Perform additional testing for all existing wiring/cables to be reinstalled/reterminated as also shown on the PLANS. Refer to the PLANS.

1.02 REFERENCES

A. This section contains references to the following codes and standards. They are a part of this section as specified. In case of conflict between the requirements of this section and the listed standards, the requirements of this section shall prevail.

Code	Title
NFPA 70-2014	National Electrical Code (NEC)
NEMA WC-70	Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy
ASTM B8	Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
UL 44	Thermoset-Insulated Wires and Cables
UL 510	Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape
UL 486	Wire Connectors
ANSI C119	Electrical Connectors

1.03 SUBMITTALS

A. Submit shop drawings in accordance with Section 01300 of the Contract Specifications.

B. Submit Operations and Maintenance Manuals (O&M) in accordance with Section 01730 of the Contract Specifications. O&M Manuals shall include copies of the approved shop drawings, factory and on-site/field test data.

C. Submit test results as described hereinafter. Additional submittals for test results associated with the reuse of existing wiring/cables is required as described hereinafter.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. All wire and cable on this project shall be new, unused, in good condition and shall be delivered in standard coils, packages or reels. Samples of all wire shall be submitted by the Contractor when so requested by the Owner for the purpose of determining acceptability of the wire. Wire and cable which has been rejected shall not be used again. Such rejected wire and cable shall, on the contrary, be removed from the Owner's premises forthwith. Decisions as to the quality of the wire and cable furnished and the acceptance of such wire and cable shall be made by the Owner or Engineer.

B. Existing cable/wire may be reused only where specifically noted on PLANS. Existing cable/wire is to be reused in accordance to the requirements of the specifications for reuse of existing cable/wire. Exercise caution in handling of existing cable/wire to be reused, so as not to damage conductor or insulator. Existing cable/wire to be reused shall be adequately protected from adverse surrounding conditions, including impact, dust, debris, moisture, sun light, and extreme temperatures. Protect cable/wire at point of exit of conduit system so as not to damage insulator. Make all necessary provisions for adequate protection of existing cable/wire to be reused.

2.02 SINGLE CONDUCTOR - GENERAL ELECTRICAL POWER SYSTEM AND AUXILIARY ELECTRICAL SYSTEM WIRING

A. General electrical power system and auxiliary electrical system wiring shall be 98% conductivity copper, stranded, single conductor Type XHHW-2. This wire shall have moisture resistant insulation and clean stripping characteristics. Wire shall be marked at a minimum distance of every ten feet (10’) with the size, type and voltage of the wires as well as the manufacturer's name. All neutral and ground wires shall be insulated, identified and marked.

B. The color of the wire shall be selected to conform in all instances to the following table:

Phase	277/480 Volts	120/208 Volts AC	125 Volts DC
ΦA	Brown	Red	----------
ΦB	Yellow	Black	----------
ΦC	Purple	Blue	----------
Neutral	Gray	White	----------
Ground	Green	Green	Green
Motor Space Heater (H)	----------	Black	----------
DC Wiring (+)	----------	----------	Blue
DC Wiring (-)	----------	----------	Brown

C. Any interlock wiring installed in one device with power from another device shall be properly marked.

D. The minimum wire size shall be #10 AWG for all wiring unless shown otherwise on the PLANS.

E. Departures from the sizes shown shall be made only in those cases in which the National Electric Code requires the use of larger conductors.

F. In no case shall there be a voltage drop greater than 1.0% at 480 volt service and 1.0% at 120/208 volt service. The Contractor may, if he deems it is necessary or advisable, use larger sized conductors than those shown on the PLANS.

G. Manufacturer: General Cable Company, The Okonite Company, or approved equal.

2.03 SIGNAL AND COMMUNICATION WIRING

A. 4-20 Milliamp Signal wiring:

1. Number of Pairs: One

2. Wire Size: #16 AWG

3. Type of Conductors: Stranded copper conductors, twisted

4. Individual Conductor Insulation: PVC

5. Individual Conductor Insulation Color: Positive (+) is Black, Negative (-) is White.

6. Drain Wire: Tinned copper

7. Overall Shield: Aluminum-mylar shield.

8. Overall Jacket: PVC

9. Overall Jacket Color: Black.

10. Manufacturer: Samuel Moore and Company, Dekoron Division, Cat. No. 1852, Belden, or approved equal.

B. Multi-Conductor RTD Temperature Signal Wiring:

1. Number of Triads: One

2. Wire Size: #16 AWG

3. Type of Conductors: Stranded copper conductors, twisted

4. Individual Conductor Insulation: PVC

5. Individual Conductor Insulation Color: Positive (+) is Black, Negative (-) is White, Sense (S) is Red.

6. Drain Wire: Tinned copper

7. Overall Shield: Aluminum-mylar shield.

8. Overall Jacket: PVC

9. Overall Jacket Color: Black.

10. Manufacturer: Samuel Moore and Company, Dekoron Division, Cat. No. 1862, Belden, or approved equal.

C. Ethernet Data Communication Wiring:

1. Refer to Section 17600 Distributed Control System.

D. Fiber Optic

1. Refer to Section 17600 Distributed Control System.

E. RS-485 Communication wiring:

1. Comply with sub-section 2.03.A, this Section of the Specifications.

2.04 SINGLE CONDUCTOR CONTROL WIRING

A. Control wiring shall be 98% conductivity copper, stranded, single conductor Type XHHW-2. This wire shall have moisture resistant insulation and clean stripping characteristics. Wire shall be marked at a minimum of every ten feet (10’) with the size, type and voltage of the wires as well as the manufacturer's name.

B. The color of the wire shall be RED.

C. The minimum wire size shall be #12 AWG for all wiring unless shown otherwise on the PLANS.

D. Manufacturer: General Cable Company, The Okonite Company**,** or approved equal.

2.05 MULTI-CONDUCTOR CONTROL WIRING IN UNDERGROUND CONDUIT/DUCT BANK SYSTEM

A. Utilize multi-conductor cables in all underground conduit system (duct banks, manholes, handholes, etc.) and in above ground conduit system where it is the continuation of cable run entering/exiting an underground conduit system (i.e., do not splice into a standard single conductor power and auxiliary electrical system wiring before or after transition of conduit system to an above ground system. All cables shall be continuous without splices from source to destination of termination and vise-versa, thus type of cable must also remain the same throughout the entire run).

B. Multi-Conductor cables for Electrical System Control Wiring shall be the shielded type and shall be rated 2000 volts. Cables shall be suitable and rated for installation in wet or dry locations, for AC or DC service at conductor temperature of 90°C. Cables shall be suitable and rated for installation in conduit system, duct bank system, cable trough system, cable tray system, and directly buried in the ground/earth.

C. Features:

As minimum, the Multi-Conductor control cables shall have the following features:

1. Excellent flame resistance. Passes the IEEE 383 Vertical Tray Flame Test at 70,000 BTU/hr and also when modified for 210,000 BTU/hr flame source utilizing the corner configuration.

2. Cables shall comply with IEEE 383 standards requirements “Type Test of Class IE Electrical Cables”.

3. Cables shall have mechanical rigidity and shall be flexible, easy to install and terminate.

4. Cables shall be resistant to water, oil, and chemicals. Cables shall also be stable at elevated temperatures.

D. Conductors:

Each individual conductor in the Multi-Conductor cables shall be copper per ASTM B-3, stranded (Class B Stranded per ASTM B-8), with 2000 volt insulation. Insulation shall be heat, moisture, flame and chemical resistant, mechanically rugged Ethylene-Propylene insulation compound. . Size of each conductor shall not be less than <u>No. 10 AWG.</u> Also refer to PLANS for additional information.

E. Assembly:

Individual conductors cabled in accordance to U.L 1277, using extruded belt and fill. A longitudinal corrugated shield consisting of a 5 mil copper tape shall be longitudinally applied over the extruded belt and fill (over entire multi-conductor and fillers assembly, and just prior to overall cable jacket).

F. Overall Jacket, Conductor sizes, Conductor Quantity, Overall Diameters:

Each Multi-Conductor cable shall be covered with overall thermoset chlorinated polyethylene jacket which shall meet or exceed the requirements of ICEA S-73-532. The jacket thickness, number of conductors, number of strands per conductor, conductor, ground wire size per cable, and cable overall diameters shall be as follows:

Total # of 2000 volts insulated conductors in cable	Current Carrying Conductor size (AWG) and (x Qty)			2000 volts Insulated ground wire size and (x Quantity)			Jacket Thick-ness in mils	Maximum Overall Outer Cable Diameter (inches)
	Size (AWG)	#of strands (min.)	Qty.	Size (AWG)	#of strands (min.)	Qty.		
7	#10	7	X6	#10	7	x1	60	0.94

G. Manufacturer:

2000 volts multi-conductor Electrical Control System Wiring Cables shall be as manufactured by Okonite-FMR-LCS Okolon TS-CPE Cable**,** or approved equal.

H. Color Coding:

The color coding of the individual conductors in a cable shall comply with the color coding requirements for the single conductors in a 120/208 volt systems, outlined under Subsection 2.02B.

2.06 CONTROL CABINET/PANEL WIRING

A. Control, power and alarm wiring within each control cabinet/panel shall be tin-plated copper, extra flexible 41-strand, single conductor Type SIS with cross-linked polyethylene (XLPE) insulation. Wire shall be marked at a minimum of every ten feet (10’) with the size, type and voltage of the wires as well as the manufacturer's name.

B. The color of the wire shall be selected to conform in all instances to the following table:

FUNCTION	COLOR CODE
Control/status signal wiring. This does not apply to control/status signal wiring that are scheduled for interface with remote Programmable Logic Controller (PLC)	Red
Control wiring to relay coils (L1 & L2 terminals or H&N terminals) that are not generated from a PLC Discrete Output point (DO)	Gray
120Vac power supply wiring to instrumentation and control devices that are not generated from a PLC Discrete Output point (DO)	Gray
125 VDC power supply wiring. Positive (+) and Negative (-) terminals.	Blue (+) and Brown (-)
24 VDC power supply wiring to instrumentation and control devices. Positive (+) and Negative (-) terminals.	Blue (+) and Brown (-)
Alarm wiring	Yellow
Wiring to instrument control cabinet interior lights/receptacle	Black = Hot White = Neutral
Control/status signal wiring to Programmable Logic Controller **(**PLC) -Discrete Input Modules (DI's as shown on the PLANS)	Violet
Control/status signal wiring from Programmable Logic Controllers (PLC's) –Discrete Output Modules (DO's as shown on the PLANS	Pink

C. The minimum wire size shall be #14 AWG for all wiring unless shown otherwise on the PLANS.

D. Manufacturer: General Cable Company, The Okonite Company, or approved equal

2.07 MISCELLANEOUS

A. Twist-on Wire Connectors:

1. Ratings:

a. Voltage: 600 volts

b. Temperature: 105° C. (221° F.)

2. Construction:

a. Insulating Housing: Flame retardant polypropylene and thermoplastic elastomer with flexible skirt

b. Spring Insert: Steel with corrosion resistant coating

3. Manufacturer: 3M Performance+ Spring Connectors, or approved equal.

B. Weatherproof Twist-on Wire Connectors:

1. Ratings:

a. Voltage: 600 volts

b. Temperature: 105° C. (221° F.)

2. Construction:

a. Insulating Housing: Thermoplastic polyester

b. Spring Insert: Zinc plated steel

c. Sealant: Pre-filled (factory-filled) with 100% Silicone-Based Sealant for maximum protection against Moisture and Corrosion.

3. Manufacturer: IDEAL Model 61, 62, or 63 WeatherProof Wire-Nut Wire Connectors, or approved equal.

C. Multi-Cable Connector Blocks:

1. Ratings:

a. Voltage: 600 volts

b. Temperature: -45° to 90° C.

2. Construction:

a. Connector Body:

1) Multiple port connector body constructed from 6061-T6 aluminum alloy

a) Wire/Conductor Sizes Up To 2/0 AWG: Single pressure screw per wire entry port.

b) Wire/Conductor Sizes Larger Than 2/0 AWG: Minimum of two (2) pressure screws per wire entry port

2) Dual rated for use with copper and/or aluminum conductors. Pre-filled with an oxide inhibitor.

3) Wire entry ports on both sides of the connector to allow access from either side.

b. Insulation: Molded, abrasion and chemical resistant, high-dielectric strength, UV rated plastisol with removeable access plugs

3. Manufacturer:

a. Wire/Conductor Sizes Up To 2/0 AWG: IPLG Series as manufactured by Polaris Electrical Connectors, or approved equal.

b. Wire/Conductor Sizes Larger Than 2/0 AWG: IPLDH Series as manufactured by Polaris Electrical Connectors, or approved equal.

D. Submersible Multi-Cable Connector Blocks:

1. Ratings:

a. Voltage: 600 volts

b. Usage: Capable of being submerged under water continuously

2. Construction:

a. Connector Body:

1) Multiple port connector body constructed from 6061-T6 aluminum alloy with manufacturer's standard spacing.

2) Dual rated for use with copper and/or aluminum conductors. Includes silicone grease and oxide inhibitor

b. Insulation: EPDM rubber insulated with removeable access plugs.

3. Manufacturer: "Connector Manufacturing Company" (CMC) Type SSBC-S, or approved equal.

E. Waterproof Streetlight Splice Kits

1. Ratings:

a. Voltage: 600 volts

b. Usage: Capable of being submerged under water continuously

2. Construction:

a. Connector Body:

1) Multiple port set screw terminal bus.

2) Dual rated for use with copper and/or aluminum conductors

b. Insulation: Thermoplastic rubber insulated

3. Manufacturer: "Ideal Industries, Inc." Buchanan Streetlight Kits, or approved equal by RAYCHEM.

F. Vertical Cable Supports:

1. Construction:

a. Body: Copper-free aluminum threaded for rigid conduit with knurled insulating inner surface.

b. Wedging Plug: One-piece impregnated hardwood plug.

2. Manufacturer: Type "S" support as manufactured by O-Z/Gedney, or approved equal.

G. Arc and Fireproofing tape:

1. Features:

a. Capable of withstanding temperatures to 23,000 deg. F (13,000 deg. K) for 70-cycles.

b. Not less than 0.76mm thick

c. Capable of cover 100% elongation.

d. Non-corrosive to metallic cable sheaths and compatible with synthetic cable jackets.

e. Self-extinguishing and shall not support combustion.

f. The tape shall not deteriorate when subjected to water, salt water, gases and sewage.

2. Manufacturer: "3M" Scotch 77, or approved equal.

H. Wire Pulling Lubricant:

1. Features:

a. Environmentally safe, non-toxic, non-flammable, and non-corrosive.

b. Safe to use with most cable types.

c. Clings to wire/cable throughout long pulls.

d. Resists breakdown or separation from exposure to hot and cold temperatures.

2. Manufacturer: Ideal ClearGlide as manufactured by Ideal Industries, or approved equal.

I. Electrical Coating/Spray:

1. Features:

    a. Electrical grade, fast drying sealer and insulating spray

    b. Protects wire surface against weather, moisture, corrosion, oil, alkalies and acids.

    c. Clear color.

2. Manufacturer: 3M Scotch 1601 Insulating Spray, or approved equal by Dow Chemical.

J. Wire Tags:

1. Rating: Flame-retardant,

2. Style: Heavy-duty industrial grade, heat shrinkable.

3. Maximum Length: 2 inches.

4. Color: Yellow.

    a. Exception: Use White for 120 volts A.C. power circuits to instrument/devices, and branch circuit lighting and convenience receptacle circuits.

5. Text:

    a. Typed with indelible marking process. Handwritten shall not be accepted.

    b. 1/8-inch minimum character height

6. Manufacturer: Raychem type Heavy-Duty Industrial Grade ShrinkMark Heat-Shrinkable Marking Sleeves, or approved equal. Utilize Raychem Portable-Marking-System complete with wire tag cartridges, or approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Before wire is pulled into any conduit, thoroughly swab the conduit to remove all foreign material and to permit the wire to be pulled into a clean, dry conduit. Use wire pulling lubricant in pulling any wire. Pull all conductors into their respective conduits by hand except where written permission of the Owner's duly authorized representative is secured to the contrary.

B. Support all conductors in vertical conduits or raceways in the manner set forth in the latest revision of the National Electric Code. Use vertical cable supports as Specified in 2.07.C, this Section of the Specifications.

C. Do not use lighting fixtures for raceways or circuits other than for parallel wiring of fixtures.

D. All wiring connections must be insulated with 600 volt insulation system.

E. No wire splices shall be accepted except as permitted below:

1. 208/120 volt lighting and receptacle circuiting:

a. IN ALL LOCATIONS EXCEPT INSIDE OF THE ENVIRONMENTALLY CONTROLLED SUBSTATION NO. 1 BUILDING, INSIDE OF THE UNDERGROUND JUNCTION BOXES/UNDERGROUND HANDHOLES (POINTS OF SPLICE BELOW FINISHED GRADE).

1) When the composition of wire quantity and sizes to be spliced/connected are NOT Greater Than three (3) #10 AWG wires utilize Weatherproof Twist-on Wire Connectors.

2) When the composition of wire quantity and sizes of the of 208/120 volts lighting and receptacle circuiting is Greater Than three (3) #10 AWG wires, utilize Multi-Cable Connector Blocks.

b. INSIDE OF THE SUBSTATION NO. 1 BUILDING:

1) When the composition of wire quantity and sizes to be spliced/connected are NOT Greater Than three (3) #10 AWG wires, utilize Twist-on Wire Connectors.

2) When the composition of wire quantity and sizes of the of 208/120 volts lighting and receptacle circuiting is Greater Than three (3) #10 AWG wires, utilize Multi-Cable Connector Blocks.

c. INSIDE OF THE UNDERGROUND JUNCTION BOXES/UNDERGROUND HANDHOLES (POINTS OF SPLICE BELOW FINISHED GRADE):

1) Utilize Waterproof Streetlight Splice Kits.

F. Where equipment is subject to vibration, such as motors of process mechanical equipment, exhaust and supply fans, unit heaters, all motors, motor operated valves, electric operated valves, transformers, air-handling units, compressors, condensing units, etc., Utilize 600 volts Multi-Cable Connector Blocks

G. After all wiring connections have been made, the Contractor shall apply the Corrosion Resistant and Moisture Repelling Electrical Coating/Spray to all wiring connections. Coordinate application with the Owner. The extent of spray application is further clarified as follows:

1. Spray shall be applied for all terminations of the following types of connections at a minimum:

a. termination points, terminals, terminal blocks, ground bar, neutral bar/bus,

b. lugs of circuit breakers, buses, doors, etc.

c. exposed/stripped ends of each conductor, etc.

d. bolt-on connections, split-bolt connections, ring lugs, etc.

e. submersible roadway connectors, compression connectors, connector blocks, etc.

f. all other connection types not listed above

2. Spray shall be applied for all terminations at the following types of equipment at a minimum:

a. Local and main control panels, field instruments, junction boxes, field control stations, control relays, signal isolators, selector switches, pushbuttons, etc.,

b. Panelboards, transformers, motor control centers, manual motor starters, contactors, light switches, light fixtures, etc.

c. Motor termination enclosures, valve actuators, cathodic protection system, package control panels of process equipment, etc.

d. Security system devices, cameras, roadway gate operators, etc.

e. Convenience receptacles, scada receptacles, etc.

f. All other types of equipment not listed above.

H. Tagging:

1. Tag all power, Instrumentation and Controls, Fiber Optic Cables, and all other types of auxiliary electrical wiring and cables at both ends with the specified heat shrinkable tags and heat shrink tags.

2. Tag per Subsection 3.03 of this Section of the Specifications and per the OWNER's cable and wire tagging standards.

3. Tag each wire in a Multi-Conductor cable in addition to the overall cable itself.

4. Group wiring routed in pullboxes that are routed in common conduits and tag each wiring group inside each pullbox with nameplates per subsection 3.03.C, this Section of the Specifications.

5. Secure each phenolic tag (where required) with a minimum of two nylon cable ties, one at each end of the tag.

I. Terminate stranded wiring by use of lugs, clamps or pressure type terminals. Do not terminate by wrapping wire around terminals.

J. Ground shielded instrument cables at one point only, i.e.; at the final destination in the associated instrument and control cabinets.

K. Conform to the requirements of Section 16800 of the Specifications.

L. Fireproof all cables in underground manholes and handholes.

M. Arrange cables (Power, Instrumentation, Controls and Fiber Optic Cables) in manholes so that there is a minimum of crossing and re-crossing. Provide enough slack in each cable to allow for contraction and to allow for future splicing. Fireproof all cables in manholes with approved arc and fireproofing tape capable of withstanding temperatures to 23,000 deg. F. Tag all cables (Power, Instrumentation, Controls and Fiber Optic Cables) in manholes. Utilize fire retardant and corrosion resistant cable tags with minimum of 3/4”-high lettering. Additionally, Tag all cables (Power, Instrumentation, Controls and Fiber Optic Cables) in manholes. Utilize fire retardant and corrosion resistant cable tags with minimum of 1½”-high lettering. Fasten cable tags with plastic wire ties at each end of cable tag to insure a secure installation.

3.02 TESTS

A. Perform all tests as outlined in Section 16800 and all other tests which are necessary to determine that the electrical wiring system is in satisfactory operating condition. Wiring shall be tested end-to-end after it is pulled in the conduit system.

B. EXISTING WIRING/CABLES WHICH ARE SHOWN ON THE PLANS TO BE DISCONNECTED, REMOVED, AND SUBSEQUENTLY REINSTALLED: Certain existing wiring/cables are shown on the PLANS to be disconnected, removed, and subsequently reinstalled. Refer to the PLANS. At minimum, perform the following tests associated with such wiring/cables:

1. Upon removal of a portion of the existing wiring/cable from the existing raceway system or upon removal of existing wiring/cable in its entirety from the existing raceway system, perform the tests as outlined in Section 16800 for all existing wiring/cables that have been removed and are to be re-installed. Test results shall be submitted for review prior to wiring/cable reinstallation.

2. Prior to re-installation of the existing wiring/cable into the raceway system, coordinate with owner for review of wire/cable.

3. Upon re-installation of the existing wiring/cables into the raceway system, perform the tests as outlined in Section 16800 for all existing wiring/cables that have been re-installed. Test results shall be submitted for review.

4. Additionally, the Contractor shall give consideration to the construction project schedule to ensure all test results are submitted for review well in advance of other testing as required by Specification Section 17100 “Process Instrumentation and Control System PICS”.

3.03 WIRE TAGGING METHODOLOGY

A. Single Conductor Wire Tagging Scheme:

1. All single conductor control and power wiring shall be tagged utilizing the source and destination method. In general, as minimum each tag shall be comprised of various fields which are:

a. Device Identifiers,

b. Terminal Numbers and,

c. Equipment Identification name

2. The following is the format that shall be used for each control power single conductor wire tag:

XXXX	-	XX	(XXXX-XXXX-XXXX	/	XXXX	-	XX)
Device Identifier		Terminal Number	Equipment Identification Name		Device Identifier		Terminal Number

a. The tag information to the left refers to the point of termination. Tag information in parenthesis refers to the point of origination. Note: For wiring within the boundaries of a piece of equipment, The Equipment identification name shall not be required, only the Device Identifier and the Terminal Number from the point of origination. Examples to this exception would be, wiring from one terminal strip to another within the same control panel, etc.

3. The following provides a brief description to each of the fields required within a single wire tag:

FIELD	DESCRIPTION
Device Identifier:	A four (4) alphanumeric character field that shall uniquely identify a device within a piece of equipment. Examples are: TB1, for Terminal Block Number 1, and CR02 for Control Relay #02, etc.
Terminal Number:	A two (2) alphanumeric character field that shall identify which specific point on the Device the wire must be terminated to. Refer to manufacturer's labeling or record drawings for Device Terminal Numbers.
Equipment Identification Name:	A twelve (12) alphanumeric character field that shall be the same as the physical Equipment Identification Nameplate attached to the equipment.

B. Single Conductor Wire Tagging Scheme in a Multiconductor Cable:

1. All single conductor control and instrument wiring (in Multiconductor Instrument or Control Cables) shall be tagged utilizing the source and destination method. In general, each tag shall be comprised of various fields which are 1) Device Identifiers, 2) Terminal Numbers, and 3) Equipment Identification Name, as minimum.

2. The following is the format that shall be used for each single conductor wire tag in a multiconductor cable (Instrumentation or Control wiring Cables):

XXXX	-	XX	(XXXX	/	XX)
Device Identifier		Terminal Number	Cable ID		Conductor Number

   a. The tag information to the left refers to the point of termination. Tag information in parenthesis refers to the point of origination.

3. The following provides a brief description to each of the fields required within a single tag (in a Multiconductor Cable):

FIELD	DESCRIPTION
Device Identifier:	A four (4) alphanumeric character field that shall uniquely identify a device within a piece of equipment. Examples are: TB1, for Terminal Block Number 1, and CR02 for Control Relay #02, etc.
Terminal Number:	A two (2) alphanumeric character field that shall identify which specific point on the Device the wire must be terminated to. Refer to manufacturer's labeling or record drawings for Device Terminal Numbers.
Cable Identification (Cable ID):	A five (5) alphanumeric character field that shall uniquely identify a cable within the facility. The first character shall identify the cable type as follows: C - for Control Cables I - for Instrumentation Cables P - for Power Cables The remaining four (4) alphanumeric characters shall make-up a unique number for a given cable type within the facility.

C. Overall Cable Tag of a Multiconductor Cable:

1. In addition to tagging each single conductor in a multiconductor cable (as described in 3.03 B, above), the overall jacket of each multiconductor cable shall also be tagged to uniquely identify each cable within the facility. In general, each cable tag shall be comprised of various fields which are 1) Cable Identification (Cable ID), and 2) Equipment Identification Name, as minimum.

2. The following is the format that shall be used for overall cable tag of each multiconductor cable:

XXXX	(XXXX-XXXX-XXXX	/	XXXX-XXXX-XXXX)
Device Identifier	Source Equipment Identification Name.		Destination Equipment Identification Name

   a. The tag information to the left refers to the actual cable Identification (name). Tag information in parenthesis refers to the Identification Name of the Equipment at point of origination (source), followed by the Identification Name of the Equipment at the point of termination (Destination Point).

3. The following provides a brief description to each of the fields required within a cable tag:

FIELD	DESCRIPTION
- Cable Identification (Cable ID):	A five (5) alphanumeric character field that shall uniquely identify a cable within the facility. The first character shall identify the cable type as follows: C - for Control Cables I - for Instrumentation Cables P - for Power Cables The remaining four (4) alphanumeric characters shall make-up a unique number for a given cable type within the facility.
- Source Equipment Identification Name:	A twelve (12) alphanumeric character field that shall be the same as the physical Equipment Identification Nameplate attached to the source (origination) equipment.
- Destination Equipment Identification Name:	A twelve (12) alphanumeric character field that shall be the same as the physical Equipment Identification Nameplate attached to the destination equipment (equipment at point of termination).

4. All cable tags shall be 3-ply engraved plastic (phenolic) attached to cable at each end of tag with nylon cable ties. All cable tags shall have background color, letter sizes, etc. as follows:

Cable Type	Tag Color	Color of Lettering	Letter Height
600 volt Power Cable	Orange	White	3/16” (min.)
600 volt Control Cable	Orange	White	3/16” (min.)
Instrumentation Cable	Black	White	3/16” (min.)

D. If, per the requirements of these specifications, a change in a cable/wire tag should occur for an existing cable/wire, then retag all portions of the cable/wire, including both ends, in accordance with the requirements of these specifications. For example, with the addition of a proposed junction box, the wires of the existing cable landed at the terminal blocks in the junction box shall be retagged to reflect the proposed junction box tag; this retagging will be also performed at the other end of the existing cable, with the tagging scheme in accordance with these specifications.

3.04 MEASUREMENT AND PAYMENT

A. No separate measurement or payment for work performed under this Section. All costs are included in the Base Bid.

END OF SECTION

SECTION 16250

BOXES AND CABINETS

PART 1 - GENERAL

1.01 SCOPE

Furnish and install all cabinets, junction boxes, pull boxes and outlet boxes as shown on the PLANS, required by the Specifications or N.E.C., or as otherwise necessary for a satisfactory operating system.

1.02 SUBMITTALS

A. Submit shop drawings in accordance with the Section 01300 of the Contract Specifications.

B. Submit Operations and Maintenance Manuals (O&M) in accordance with Section 01730 of the Contract Specifications. O&M Manuals shall include copies of the approved shop drawings, factory and on-site/field test data.

PART 2 - PRODUCTS

2.01 JUNCTION AND PULL BOXES

A. Lighting and power, signal, telephone, voice communication, instrumentation and controls, and any other junction and pull boxes hereinafter specified or shown on the PLANS shall be watertight and corrosion resistant as follows:

1. With the exception of the areas listed below, boxes installed in ALL AREAS shall be NEMA-4X 316 gauge stainless steel. Boxes shall be equipped with hinged doors complete with 1/4 (quarter) turn door latches. Boxes shall have a smooth, non-brushed finish. The areas of exception are:

    a. Environmentally and climate controlled ELECTRICAL ROOMS located at the:

        1) SUBSTATION NO. 1 BUILDING

2. Boxes installed inside the environmentally and climate controlled ELECTRICAL ROOMS of the SUBSTATION NO. 1 BUILDING, shall be NEMA-12 dustight/oiltight. Boxes shall be equipped with hinged doors complete with ¼(quarter) turn door latches. All NEMA-12 boxes shall have ANSI #61 Gray finish.

B. Boxes or cabinets shall be not less than 6-inches deep and their size determined by the requirements of, and in compliance with the National Electrical Code (NEC).

C. Stainless steel junction and pull boxes shall be as manufactured by Hoffman Concept Series, Rittal, or approved equal.

D. Painted steel junction and pull boxes shall be as manufactured by Hoffman Concept Series, Rittal, or approved equal.

E. Aluminum junction and pull boxes shall be as manufactured by Hoffman Comline Series, Rittal, or approved equal.

2.02 DEVICE BOXES FOR CONVENIENCE/SPECIAL PURPOSE RECEPTACLES AND LIGHT SWITCHES

A. Boxes for convenience/special-purpose receptacles shall be as specified in Section 16300 "Wiring Devices".

B. Boxes for Light Switches shall be as specified in Section 16300 "Wiring Devices".

2.03 OUTLET BOXES

A. All outlet boxes installed indoors and outdoors shall be of one piece construction. All boxes shall be provided with covers of the same manufacture as the boxes. Boxes shall be used for ceiling or wall mounting of light fixtures.

B. Boxes installed outdoors shall be Die Cast Aluminum, 99.0% copper-free, with mounting ears (QTY: 2-per box). Boxes shall be manufactured by Crouse-Hinds type FS-SA and FD-SA, with above options/accessories, Appleton, or approved equal. Associated blank coverplates shall be Die Cast Aluminum, 99.0% copper-free, with rubber gasket, as manufactured by Crouse-Hinds, or approved equal. All mounting hardware shall be 316-stainless steel.

C. Boxes installed indoors in ALL architecturally unfinished AREAS in which the wall finish is of Concrete or Concrete Masonry Unit (CMU, of any type) block walls, boxes shall be Die Cast Aluminum, 99.0% copper-free, with mounting ears (QTY: 2-per box). Boxes shall be manufactured by Crouse-Hinds type FS-SA and FD-SA, with above options/accessories, Appleton, or approved equal. Associated blank coverplates shall be Die Cast Aluminum, 99.0% copper-free, with rubber gasket, as manufactured by Crouse-Hinds, or approved equal. All mounting hardware shall be 316-stainless steel.

D. On all ceiling outlets involving fixtures hanging from boxes, use 316-stainless steel gasketed device covers for ALL AREAS except for inside the environmentally and climate controlled ELECTRICAL ROOMS of the buildings described in Subsection 2.01 A. 1. a. above. In the same environmentally and climate controlled ELECTRICAL ROOMS, use 99.0% copper-free Die Cast Aluminum gasketed device covers. Provide boxes with 3/8" no-bolt fixture studs for light loads and ½" no-bolt fixture studs for heavy loads. In instances in which fixtures are hung from pipe stems, use swivel hanger covers. These swivel fittings shall have cushioned mechanisms permitting natural swinging of fixtures similar to Crouse-Hinds ball type fixture hanger series ARB. Fixture hangers shall be made of the same material and have the same finish as the outlet boxes. Refer also to details shown on the PLANS, as applicable.

E. Coordinate final location of boxes with other trades to avoid any conflicts.

2.04 NAMEPLATES

A. General:

1. Type: 3-ply phenolic laminated

2. Color: Black-White-Black

3. Lettering: 1/4 inch height, minimum, engraved

4. Accessories: Provide adhesive backplane where required in Part 3, Execution.

PART 3 - EXECUTION

3.01 APPLICATION

A. General:

1. Pullboxes shall be used only to reduce the number of bends for conduit, supports, taps, troughs and similar applications. No splicing shall be performed in pullboxes.

2. Junction boxes shall only be used where shown on the PLANS. Any other use of junction boxes other than for receptacle and lighting circuit wiring, <u>is not permitted</u>.

3. Outlet boxes shall be used for ceiling or wall mounting of light fixtures, receptacles, open type manual motor starters, and where required by the PLANS and Specifications to facilitate proper connection to equipment.

3.02 INSTALLATION

A. Set box square and true with building surfaces. Secure boxes firmly to support channels. Equipment support channels shall be per the requirements of Section 16150 “Raceways, Fittings, and Supports”.

B. Do not mount surface mounted device and outlet boxes directly to building/structure walls. Utilize 316-stainless steel support channels, then secure/mount device and outlet boxes to the support channels. All mounting hardware shall be 316-stainless steel and shall include split ring lock washers. Additionally, refer to details shown on the PLANS.

C. Tagging:

1. Tag each box with the name as it appears on the PLANS using the specified namplates. Exception: Use nameplates specified in Section 16300 “Wiring Devices” for manual motor starters located in environmentally controlled rooms, light switches, and outlet boxes.

2. Attach identification nameplates with two stainless steel screws.

D. Maintain symmetry of all outlets as closely as possible within the Architectural Section contained. For example, center a light fixture over a doorway, or a receptacle in a section of wall, if shown in that approximate position.

E. Verify location of outlets and switches in finished rooms. In centering outlets and locating boxes, allow for overhead pipes, and mechanical equipment; etc., and correct any inaccuracy from failure to do so without extra expense to the Owner.

F. Locate light switches on the latch side of the door. Verify door hinge location in the field prior to the switch outlet installation.

G. Cap all outlets not used under this Contract with blank outlet covers.

H. Refer to Specification Section 16300 for mounting heights of receptacle and light switch device boxes.

I. Mount receptacle boxes at minimum of 6-inches above counter tops to centerline of receptacle boxes. Also refer to the PLANS.

J. When "gang" arrangements of outlets are employed, use 2-3/4" deep "gang" boxes of the specified manufacturer Model/Series.

K. Provide a "HIGH VOLTAGE" warning sign in accordance with OSHA regulations and as approved by the Owner's Safety Representative for all junction and pull boxes containing systems over 600 volts. Attach warning signs to junction and pull boxes with stainless steel hardware.

3.03 MEASUREMENT AND PAYMENT

A. No separate measurement or payment for work performed under this Section. All costs are included in the Base Bid.

END OF SECTION

SECTION 16300

WIRING DEVICES

PART 1 - GENERAL

1.01 SCOPE

A. Furnish and install all necessary wiring devices at the locations indicated on the Plans and elsewhere as required.

B. Comply with the requirements of Specification Sections 16250 and 16800.

1.02 SUBMITTALS

A. Submit shop drawings in accordance with Section 01300 of the Contract Specifications.

B. Submit Operations and Maintenance Manuals (O&M) in accordance with Section 01730 of the Contract Specifications. O&M Manuals shall include copies of the approved shop drawings, factory and on-site/field test data.

PART 2 - PRODUCTS

2.01 LIGHT SWITCHES INSIDE THE ENVIRONMENTALLY AND CLIMATE CONTROLLED SUBSTATION NO. 1 ELECTRICAL EQUIPMENT ROOM

A. This subsection covers light switches that shall be installed indoors inside the environmentally and climate controlled SUBSTATION NO. 1 CONTROL AND MECHANICAL SPACES.

B. Light switches shall be specification grade, 20 amp, 120/277 volts, switches (single pole through four-way respectively). Switching device coverplate shall be Aluminum 99.0% copper-free, complete with rubber gasket, as manufactured by the same manufacturer as the device box and recommended by manufacturer to fit the device box.

C. Light switch device boxes shall be Die Cast Aluminum, 99.0% copper-free, Single and Multi-Gang device boxes, as manufactured by Crouse-Hinds type EDSM and EDSC double-gang (as minimum) and multigang device boxes (Feed-through or dead-end configuration, as required), or approved equal by Appleton, Killark, or approved equal.

D. All mounting hardware shall be 316-stainless steel.

2.02 LIGHT SWITCHES INSIDE ELECTRICAL ROOMS THAT ARE ENVIRONMENTALLY AND CLIMATE CONTROLLED

A. This subsection covers light switches that shall be installed indoors inside the environmentally and climate controlled electrical rooms of the SUBSTATION NO. 1 ELECTRICAL EQUIPMENT SPACE.

B. Light switches shall be specification grade, 20 amp, 120/277 volts, switches (single pole through four-way respectively and momentary action spring return to center position where required on the PLANS). Switching device coverplate shall be Aluminum 99.0% copper-free, complete with rubber gasket, as manufactured by the same manufacturer as the device box and recommended by manufacturer to fit the device box.

C. Light switch device boxes shall be Die Cast Aluminum, 99.0% copper-free, Single and Multi-Gang device boxes, as manufactured by Crouse-Hinds type EDSM and EDSC double-gang (as minimum) and multigang device boxes (Feed-through or dead-end configuration, as required), or approved equal by Appleton, Killark, or approved equal.

D. All mounting hardware shall be 316-stainless steel.

2.03 LIGHT IN ALL OUTDOOR AREAS

A. This subsection covers light switches that shall be installed in all OUTDOOR areas.

B. Light switches shall be Specification grade, 20 amp, 120/277 volts, switches (single pole through four-way respectively). Switches shall be Factory-Sealed-Switches where each switch is enclosed in a unique sealing well with double flanges that mate with the light switch cover and box assembly. Light switches shall be raintight, corrosion resistant, and rated for use in wet locations and in Class-I Division-2 hazardous areas (as classified by NEC). Light switches shall be as manufactured by Crouse-Hinds, Killark, or approved equal.

C. The light switch cover shall have an external front operator (for snap switches). The cover shall be Die Cast Aluminum, 99.0% copper-free, watertight and corrosion resistant. In a group installation, provide manufacturer's assemblies for two gang tandem, three, four and/or five gang bodies (device boxes). Light switch covers shall be as manufactured by Crouse-Hinds, Killark, or approved equal.

D. Light switch device boxes shall be Die Cast Aluminum, 99.0% copper-free, Single and Multi-Gang device boxes, as manufactured by Crouse-Hinds type EDSM and EDSC double-gang (as minimum) and multigang device boxes (Feed-through or dead-end configuration, as required), or approved equal by Appleton, Killark, or approved equal.

E. All mounting hardware shall be 316-stainless steel.

2.04 120 VOLTS AC, COVENIENCE RECEPTACLES INSIDE THE ENVIRONMENTALLY AND CLIMATE CONTROLLED SUBSTATION NO. 1 ELECTRICAL EQUIPMENT ROOM

A. This subsection covers receptacles that shall be installed indoors inside the environmentally and climate controlled SUBSTATION NO. 1 ELECTRICAL EQUIPMENT ROOM.

B. Standard receptacles shall be Hubbell No. 5362-I, or equal by Bryant**,** Pass and Seymour, or approved equal. Receptacles shall be duplex, 3-wire, polarized grounding type, rated 20 amp, 125 volt, 60 Hertz.

C. Receptacle boxes shall be Die Cast Aluminum, 99.0% copper-free, Single and Multi-Gang device boxes, as manufactured by Crouse-Hinds type EDSM and EDSC double-gang (as minimum) and multigang device boxes (Feed-through or dead-end configuration, as required), or approved equal by Appleton, Killark, or approved equal.

D. Receptacle coverplates shall be Aluminum 99.0% copper-free, complete with rubber gasket, as manufactured by the same manufacturer as the device box and recommended by manufacturer to fit the device box.

E. Provide Pass & Seymour Cat. No. 2095 ground fault interrupter type receptacles with red indicator light, where G.F.I. receptacles are indicated.

F. All mounting hardware shall be 316-stainless steel.

2.05 120 VOLTS AC, COVENIENCE RECEPTACLES IN ALL OUTDOOR AREAS

A. This subsection covers receptacles that shall be outdoors in ALL AREAS, including receptacles mounted on exterior walls/structural members of buildings/structures.

B. Receptacles shall be specification grade, 20 amperes, 120 volts, Pin and Sleeve, 2-wires, 3-poles, dead-front, twist-lock Factory-Sealed, Pin and Sleeve, interlocked, circuit breaking Receptacles. Receptacles shall be watertight, raintight, corrosion resistant, and rated for use in wet locations and in Class-I Division-2 hazardous areas (as classified by NEC). Additional features of the receptacles shall be:

1. Type 12 nylon (KRYDON) water proof and corrosion resistant enclosure

2. Brass receptacle blades/contacts

3. 316 Stainless Steel hardware

4. Mechanically interlocked plug and receptacle where plug cannot be engaged or disengaged under load

5. Internal switch that shall activate only after the Plug is inserted into the receptacle and twisted. Switch shall be horsepower and AIC-rated

6. Receptacle furnished complete with manufacturers matching device box (back-box). Device box shall be waterproof and corrosion resistant KRYDON enclosure and NEMA-

4X rated as well as suitable for use in Class-I Division2 hazardous areas (as classified by NEC). Device box shall be furnished with minimum hub sizes and quantity of hubs as required to comply with the circuiting and conduit/wire size requirements shown on the PLANS).

7. The receptacle shall be furnished with fully gasketed watertight, dustight, and corrosion resistant TWIST-ON cover

8. The receptacle, Plug and Device Box assembly shall be bare the following CERTIFICATIONS:

    a. Class-I, Division 2, Groups A, B, C & D product,

    b. U.L

    c. P66 and NEMA-4X, and C.E.

C. Receptacles shall be as manufactured by Crouse-Hinds Series IEC-309 Hazardous Area Receptacles/Plugs and Interlocks, Factory-Sealed, TYPE GHG Pin and Sleeve receptacles complete with device boxes and specified accessories.

D. All mounting hardware shall be 316-stainless steel.

E. Furnish and install a total count of Two (2) Sets of completely assembled matching CORD and PLUG assembly for the 120 volt AC 20 ampere rated Receptacles. Each set of the CORD and PLUG assemblies shall be furnished complete with matching and pre-made cord and plug assembly. The cord and plug assembly (of each set) shall consist of matching Male plug, and 120 volt rated 20-ampere, 3-conductor extra-flexible 25-feet long power cord (each conductor shall be 100%-conductive-soft-copper conductors with 41-strands). Each conductor in the 3-conductor power cable shall be #12AWG rated for 20 amperes continuous current draw at 120 volts AC. The 3-conductor cable shall be Type SO-CORD. The total length of each 3-conductor power cord shall be 25-feet. One end of each of the flexible power cord assemblies shall be terminated to the matching Male plug of the associated receptacle, the plug shall be 120 volts rated 20-ampere, 2-wires, 3-poles, watertight and corrosion resistant and rated for use in wet locations and in Class-I Division-2 hazardous areas (as classified by NEC), as manufactured by Crouse-Hinds Series IEC-309 Hazardous Area Plugs and Interlocks TYPE GHG Pin and Sleeve Twist-On plug. The other end of each conductor in the 3-conductor cord (of each of the flexible power cord assemblies) shall be terminated to 120 volts AC, rated 20-ampere, tin-plated-copper spade-connectors.

2.06 125 VOLTS DC, COVENIENCE RECEPTACLES INSIDE THE ENVIRONMENTALLY AND CLIMATE CONTROLLED SUBSTATION NO. 1 ELECTRICAL EQUIPMENT ROOM

A. This subsection covers 125 volts DC receptacles that shall be installed indoors inside the environmentally and climate controlled SUBSTATION NO. 1 ELECTRICAL EQUIPMENT ROOM.

B. Receptacles shall be 125 volts DC, 3-wire (+,- and ground), rated 30-amperes. Receptacle assembly shall be Twist Lock, Safety-Shroud and Water-Tight type.

C. Each DC receptacle shall be furnished complete with Male plug, and 600 volt, rated 50-ampere, 3-conductor flexible power cord (each conductor shall be 100%-conductive-soft-copper conductors with 41-strands). The minimum length of each flexible power cord shall be 25-feet. One end of the flexible power cord shall be terminated to the Male plug of the associated receptacle, the other end of the cord shall be terminated to a 50-ampere rated tin-plated-copper spade-connectors.

D. Tag each conductor of each power cord furnished with each DC power receptacle. Tags shall identify Positive (+), Negative (-), and Ground (GND) wires. Wire tags shall be the heat shrinkable type as specified in Section 16200 of the Contract Specifications "Wiring (600 Volts and Below)".

E. The Direct Current "DC" 125 volts DC receptacle assembly shall be as manufactured by HUBBELL Water-Tight Safety-Shroud Twist-Lock System Catalog Number HBL2610SW Receptacle, HBL2611SW Male Plug complete with safety shroud, 3-conductor type SO-Cable (50-ampere rated) with specified lugs, and NEMA-4 metallic box with Spring-Loaded-Cover.

F. All mounting hardware shall be 316-stainless steel.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Mount light switches at 48" above finished floor to the center of the switches unless otherwise noted. Locate switch on the side of the door opening opposite the hinges and as shown on the PLANS.

B. Mount receptacles at 36" above finished floor (to the bottom of the receptacles) in all areas (unless otherwise noted on the PLANS).

C. Mount receptacles that deliver DC (Direct Current) Operating Voltage at 54" above finished floor (to the center of the receptacles) in all areas (unless otherwise noted on the PLANS).

D. Test wiring devices in accordance to Section 16800 of the contract specifications.

E. Identify all 120VAC receptacles, special purpose outlets, and light switches by branch circuit number. Example, for a light switch that is powered by circuit "LP-23", the identification nameplate on the face of the light switch shall read "ckt. LP-23". Similarly, the same applies for all special purpose outlets and 120VAC receptacles. Identification nameplates shall be 3-ply phenolic ""Black-White-Black" laminated nameplates with adhesive backplane.

F. Identify all 125 volts DC receptacles by branch circuit number and voltage level. Example, for 125 volts DC receptacle powered by circuit DC Power Distribution Panel "SUB1-PDP-DC01" circuit #2 and #4, the identification nameplate on the face of the receptacle shall read "125 volts DC" (first line), "ckt. No. 2 & 4" (second line), "SUB1-PDP-DC01" (third line). Identification nameplates for each 125 volts DC receptacle shall be 3-ply phenolic "Blue-White-Blue" laminated nameplates with adhesive backplane.

G. Provide 6-inches offset for receptacles or other wiring devices mounted on opposite sides of a wall. Do not mount back-to-back.

H. All receptacle and switch boxes installed outdoors and indoors shall be of one piece. All boxes shall be provided with covers of the same manufacture as the boxes. The type of cover selected must meet the conditions imposed in every case.

I. Do not use switch boxes as junction boxes for switch and receptacle.

J. Set boxes square and true with building surfaces. Secure boxes firmly to support channels.

K. Do not mount surface mounted device and outlet boxes directly to building/structure walls. Utilize 316-stainless steel support channels, then secure/mount device and outlet boxes to the support channels. Support channels shall be per the requirements of Section 16150 "Raceways, Fittings, and Supports". All mounting hardware shall be 316-stainless steel. Additionally, refer to details shown on the PLANS.

L. Maintain symmetry of all devices as closely as possible within the Architectural Section contained. For example, center a light fixture over a doorway, or a receptacle in a section of wall, if shown in that approximate position.

M. Verify location of receptacles and switches in finished rooms. In centering devices and locating device boxes, allow for overhead pipes, and mechanical equipment; etc., and correct any inaccuracy from failure to do so without extra expense to the Owner.

N. Locate light switches on the latch side of the door. Verify door hinge location in the field prior to the switch outlet installation.

O. Cap all device boxes not used under this Contract with blank outlet covers.

P. When "gang" arrangements of outlets are employed, use 2-3/4" deep "gang" boxes of the specified manufacturer Model/Series (unless otherwise noted on the PLANS or specified herein otherwise. Note: boxes in CMU block walls shall not be less than 3-1/2" deep).

3.02 MEASUREMENT AND PAYMENT

A. No separate measurement or payment for work performed under this Section. All costs are included in the Base Bid.

END OF SECTION

SECTION 16350

LIGHTING

PART 1 - GENERAL

1.01 SCOPE

A. Furnish and install lighting fixtures and outdoor lighting time switches as specified herein and as indicated on the PLANS.

1.02 RELATED REQUIREMENTS

A. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

1.03 SUBMITTALS

A. Submit shop drawings in accordance with Section 01300 of the Contract Specifications. Submit a lighting fixture brochure for each fixture indicating pertinent physical characteristics and complete photometric data.

B. Submit Operations and Maintenance Manuals (O&M) in accordance with Section 01730 of the Contract Specifications. O&M Manuals shall include copies of the approved shop drawings, factory and on-site/field test data.

1.04 SPARE PARTS

A. Provide quantities of spare parts as follows:

1. Spare Lamps:

   a. Flourescent fixture type: Ten percent spare lamps for each type specified, with minimum of 24 lamps of each type.

   b. LED fixture type: Ten percent spare LED lamp modules for each type specified, with minimum of 6 lamp modules of each type.

2. Spare Ballasts: Five percent spare ballasts for each type specified, with minimum of 6 ballasts of each type

3. Spare Drivers: Five percent spare LED drivers for each type specified, with minimum of 6 drivers of each type

4. Photocells: Provide 3 spare photocells of each type specified.

5. Lighting Contactor: Provide one spare operating coil and two-wire control accessories.

PART 2 - PRODUCTS

2.01 GENERAL

A. Furnish fixtures in accordance with the lighting fixture schedule on the Plans. Fixtures shall bear the U.L. label and such labels shall apply to entire fixture as installed.

2.02 ACCESSORIES

A. Deliver all fixtures complete with suspension accessories, canopies, hickeys, casings, sockets, holders, reflectors, ballast, diffusers, frames, recessing boxes, etc.

2.03 LAMPS

A. Furnish type and size shown on the Fixture Schedule. Deliver to job site in original cartons. General Electric, Sylvania, or equal.

B. Install new lamps in all fluorescent light fixtures immediately prior to final inspection

2.04 BALLASTS

A. Furnish type and size shown on the Fixture Schedule.

2.05 DRIVERS

A. Furnish type and size shown on the Fixture Schedule.

2.06 PROTECTION

A. Protect all fixtures, lenses and louvers from damage. Leave protective coverings on lenses and louvers until fixtures are installed. Replace all damaged lenses and louvers immediately prior to final inspection at no cost to the Owner.

2.07 SUBSTITUTIONS

A. Comply with requirements of the Contract Specifications.

2.08 PHOTOCELL FOR OUTDOOR AND PERIMETER LIGHTING CONTROL

A. Photocell (Photo-electronic Controller) shall be 180 swivel type furnished with 3/4” conduit nipple, metallic gray polycarbonate enclosure (i.e., all lexan enclosure), light level selector

for “ON/OFF” adjustment, and minimum of two(2) minutes built-in delay to prevent false switching caused by light from vehicles, lighting etc. Photocell contacts shall be rated for 120Vac operating voltage and/or 208Vac operating voltage (as shown on the PLANS), dry contact output. Photocell shall be furnished complete with NEMA-4X stainless steel gasketed outlet box coverplate complete with 3/4” threaded opening for Photocell mounting. Photocell shall be manufactured by TORK catalog No. 2002 (208volts AC units) and TORK catalog No. 2001 (120 volts AC units)**,** or approved equal.

2.09 POLES

A. Round tubular tapered Aluminum 6063-T6 pole with integral mounting base and continuously welded joints. Pole shall be uniformly tapered along its height. Base material shall be 356-T6 aluminum. Entire assembly of light pole and base shall be heat treated to T6 temper. Drill holes in base for anchor bolts.

B. Pole diameter shall be 8-inch (diameter as measured at bottom of pole) pole shaft, 0.156 inch wall thickness at minimum. Increase size as required to support the load with a wind speed of 100 miles per hour, at minimum, at no additional cost to the Owner. Provide pole length as required in accordance with the requirements of the PLANS.

C. Pole shall have a handhole welded into pole shaft, with minimum of 3” x 5” sized rectangular opening. Provide with bolted and gasketed field removable cover. Provide oversized handhole as required to facilitate wiring installation.

D. Pole finish shall be powder coated per manufacturer’s standard process. Finish shall be applied to both the interior and exterior of the pole as well as both sides of the base, base cover, handhole cover, accessories, etc. i.e., all surfaces. Finish color shall be Dark Bronze. Coordinate final finish color with the Owner at no additional cost to the Owner.

E. Accessories:

   1. Bolted pole top cap with retainer

   2. Grounding lug

   3. Wind vibration dampeners

   4. Pole cover collar.

   5. Grounding lug

   6. Additional accessories as required by the PLANS.

F. Manufacturer: NAFCO International “Round Tapered Aluminum Pole” or approved equal.

2.10 CONTACTOR FOR INDOOR AND/OR OUTDOOR LIGHTING CONTROL (STAND-ALONE-TOTALLY-ENCLOSED)

A. Furnish and install indoor and outdoor lighting contactors and associated controls, as shown and called for on the PLANS. This subsection applies to stand-alone lighting Contactors (contactors that are not integral part of a distribution panelboard, OR lighting panelboards).

B. Contactor panel shall consist of Four (4) pole single throw Normally Open (N.O.) contacts. For the 208/120 volts Lighting Contactors, minimum continuous current rating of the contacts shall be 225 amperes at 208 volts AC, unless otherwise shown to be greater than 225 amperes on the PLANS. The contactors control coils of the 208/120 volts lighting contactors shall be 120VAC control coils. All lighting Contactors shall have a U.L. listed minimum RMS symmetrical short circuit current rating equal to or greater than the minimum RMS symmetrical short circuit current rating shown on the PLANS. However, under no circumstances shall the U.L. listed minimum RMS symmetrical short circuit current rating be less than 22,000 amperes at 208 volts AC (for 208 volts AC rated Contactor assemblies).

C. Contacts of all lighting contactors shall be suitable to drive Ballast Tungsten and Inductive Loads. Contactor assembly shall be manufactured by "General Electric Company "G.E." Series CR360L with specified accessories, or approved equal.

D. Enclosure and Control Devices shall be per specification section 17200 Instrumentation and Control Cabinets and Associated Equipment.

PART 3 - EXECUTION

3.01 INSTALLATION AND TESTING

A. Install lighting fixtures at the locations shown on the PLANS. Maintain perfect horizontal and vertical alignment of fixtures throughout.

B. Do not locate splices or taps within an arm, stem or chain.

C. Locate fixtures where shown on the PLANS. Obtain approval of any location differing from the location shown on the PLANS.

D. Replace any damaged fixture or lens at no cost to the Owner.

E. Install new lamps in all fluorescent fixtures just prior to final inspection of the project.

F. Support all pendant fixtures with swivel type hangers.

G. Install recessed luminaries to permit removal from below, to gain access to outlet or prewired fixture box.

H. Locate fixtures to avoid interference with piping, fans, ducts, and other obstructions. Obtain approval of any location differing from the location shown on the PLANS.

I. Test lighting system per Section 16800.

J. Refer to specification Section 16200 “Wiring (600 Volts and Below)” for special and specific field wiring termination requirements.

K. Fireproof all cables in underground manholes, handholes and wiring termination boxes. Additionally, apply two (2) layers of 600-volt rubber tape, then three (3) layers of Scotch No. 88 vinyl electrical tape to each bundle of single conductor 208-volt lighting circuit wiring routed in an underground manhole, handhole or wiring termination box. A bundle of wiring represents only the sum of wiring associated with a conduit, but routed in an underground manhole, handhole or wiring termination box prior to entering (or after exiting) its associated conduit within the conduit/duct bank system that is entering/exiting the associated underground manhole, handhole or wiring termination box. Thus, the single conductor wiring contained inside each conduit shall be considered a bundle and shall be independent from bundles of wiring of other conduits entering/exiting the associated underground manhole, handhole or wiring termination box.

3.02 MEASUREMENT AND PAYMENT

A. No separate measurement or payment for work performed under this Section. All costs are included in the Base Bid.

END OF SECTION

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SECTION 16444

COMBINATION MOTOR STARTERS

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Furnished all labor, materials, equipment and incidentals required to provide, and make ready for operation, the Combination Motor Starters as specified herein.

1.02 RELATED WORK NOT INCLUDED

A. Contract drawing designated type, number, size and rating of devices included in the Combination Motor Starters.

B. Comply with the requirements of Section 16800 “Calibration, Testing and Setting”.

1.03 QUALIFICATIONS

A. The manufacturer of the Combination Motor Starters shall also manufacture the majority of components and subsystems therein (i.e., circuit breakers, starters, controls relays, etc.)

B. The Combination Motor Starters shall be designed, constructed, and tested in accordance with the latest applicable requirements of NEMA, ANSI, UL, and NEC standards

C. All starters and contactors shall be rated and designated in accordance with NEMA standards. Starters and contactors rated in amperes without manufacturers published data indicating the corresponding NEMA sizes will not be acceptable. So Called International and/or “IEC” rated starters will not be acceptable.

D. For specific requirements on the Combination Motor Starters, refer to the PLANS.

E. The Combination Motor Starters shall be furnished as completely factory assembled units meeting the requirements of the PLANS and Specifications.

F. Combination Motor Starters shall be shall be as manufactured by Cutler Hammer, General Electric Company “G.E.”, Square D, Allen-Bradley**.**

1.04 SUBMITTALS

A. Submit shop drawings in accordance with the requirements of Section 01300 of the Contract Specifications. Include unit dimensions, wiring diagrams, component listings by manufacturer, catalog numbers, nameplate schedules, and overall individual equipment

control schematic including those that are not installed in the Combination Motor Starters, but shown on the control schematics of the PLANS.

B. Full nameplate information in accordance with the latest edition of NEMA MG1-10.37, Locked Rotor Current Service Factor, and efficiency at power factor at full load for applicable motor that starter is provided for.

1.05 OPERATION AND MAINTENANCE MANUALS

A. Furnish Operation and Maintenance Manuals in accordance with the requirements of Section 01730 of the Contract Specifications. Include:

1. Installation and operation manual.
2. Renewal parts bulletin.
3. Component description, rating, catalog number etc.
4. Vendor drawings.
5. As-built drawings.
6. Test data.
7. Full equipment nameplate information in accordance with the latest edition of NEMA MG1-10.37, Locked Rotor Current Service Factor, and efficiency at power factor at full load for applicable motor that starter is provided for.

1.06 STORAGE AND HANDLING

A. Deliver to job site in moisture free protective coating

B. Energize the space heaters within the Combination Motor Starters during storage and installation for humidity control.

C. At all times the Combination Motor Starters shall be housed inside a moisture free, non-porous, extra heavy duty plastic weatherproof housing

1.07 TOOLS AND SPARE PARTS

A. Furnished the following spare parts with the equipment for EACH Combination Motor Starter unit in conformance with the specifications:

1. One set (minimum 2) of spare fuses for each type and size used.
2. One set of spare starter contacts.
3. One spare contactor coil.

4. One spare control relay for each type used. Control relay shall be furnished complete with relay coils, Four (4) Normally Open (N.O.) contacts, Four (4) Normally Closed (N.C.) contacts, and shall be furnished with Relay Manufacturer's Transient Voltage Suppression Module.

5. One spare push-button, selector switch, and indicating light.

6. Two spare pilot light lamps.

7. One spare lens for each type and color size used.

8. One set of overload heaters.

PART 2 - PRODUCT

2.01 GENERAL

A. For additional construction notes and special requirements, refer to the PLANS.

2.02 CONSTRUCTION

A. Enclosure:

1. Except where otherwise specifically noted in this specification section, each Combination Motor Starter (with associated accessories) installed shall be housed in a NEMA-4X gasketed 304-Stainless Steel enclosures (cabinets), the rigidity and gauge of steel to be as specified in U.L. Standard 50 for cabinets. Enclosures shall have a smooth, non-brushed finish. Each Combination Motor Starter (with associated accessories) installed **inside** the environmentally and climate controlled SUBSTATION NO. 1 BUILDING_shall be housed in a NEMA-12 gasketed metal enclosure (cabinet), the rigidity and gauge of steel to be as specified in U.L. Standard 50 for cabinets. Each Combination Motor Starter shall be furnished with removable lifting facilities as well as basic construction designed for rolling or skidding.

2. Each Combination Motor Starter unit shall be interlocked mechanically with the unit's protective/disconnect device to prevent unintentional opening of the door while unit is energized. An interlock between the unit disconnect and the structure shall prevent the removal or reinsertion of the unit when the unit is not in the "OFF" position. Means shall be provided for releasing the interlock for intentional access and/or application of power. The unit shall be equipped with pad locking arrangements to permit locking the disconnect/protective device in the "OFF" position.

3. Furnish documentation with equipment as follows: A card holder on the inside of the door with the branch circuits clearly identified. An overload heater section table shall be posted inside the door. Provide a pocket on the inside of the door with a copy of the appropriate schematic and wiring diagrams.

4. Provide screw on type engraved laminated nameplates as follows: Main equipment nameplate shall be located at the top of the enclosure near the external handle of the disconnect/protective device. Individual nameplates shall be screwed to the door. Control device nameplates for all devices screwed on near the vicinity of each device as approved by the Owner/Engineer and as shown on the PLANS. A manufacturer's plaque shall be attached to the each Combination Motor Starter giving model number, ampere, NEMA Starter size, operating voltage, maintenance reference documents, and other applicable information.

5. Each Combination Motor Starter shall include at least one 120 volt, 250 watt space heater thermostatically controlled and wired to the control power transformer inside the enclosure, through terminal blocks. The proposed thermostat shall have an indication of ambient temperature inside the motor starter enclosure and shall have a field adjustable setpoint.

6. Furnish lugs for incoming line feeders, sizes shall be as required by the electrical one-line diagrams shown on the PLANS. Allow adequate clearance for bending and terminating to cable type specified.

B. Ground Bar:

Furnish and install a tin plated 100% rated copper ground bar in each Combination Motor Starter assembly. Provide ground bolted connectors for #6 AWG wire at each end of the bar.

C. Wiring:

1. All Control wiring shall be stranded copper not smaller than #14.

2. All wiring shall be neatly bounded with tie-wraps and supported to wire ways supports.

3. One spare Normally Open (N.O.) and one Normally Closed (N.C.) contact on all relays, selector switches, push buttons, "M" contact, alarm points, etc. shall be wired to terminal blocks.

D. Identification:

1. The Combination Motor Starter identification nameplates shall include the device name and number exactly as it appears on the Combination Motor Starters One-Line-Diagrams, control schematics and/or as approved by the Engineer.

2. All control wires shall be tagged and coded with an identification number. Tagging type and wire coding shall be per manufacturer's standard.

3. All terminal blocks shall be identified.

4. Identification nameplates mounted on the Combination Motor Starter enclosure doors shall be Laminated 3-ply Phenolic, "Black-White-Black", plastic nameplates with Roman Gothic 3/8-inch lettering for each unit compartment door, attached with stainless steel screws. Type of nameplate and lettering/size to tag/identify all components (relays, overloads, terminal strips/blocks, fuse blocks, etc.) inside the enclosure of each Combination Motor Starter cabinet shall be per manufacturer's standard.

E. Each Combination Motor Starter cabinet shall not exceed the dimensions shown on the PLANS.

2.03 COMBINATION UNITS

A. Provide adjustable instantaneous trip magnetic only motor circuit protector type circuit breakers; minimum acceptable NEMA size starter shall be NEMA size 1; and handle lock-off padlock attachment. Each combination unit (motor circuit protector and starter assembly) shall have a U.L. listed minimum RMS symmetrical short circuit current rating equal to or greater than the minimum RMS symmetrical short circuit current rating indicated on the one-line diagram drawings at 480 volts A.C. Each motor starter shall have a 120 volt operating coil. International type starters (IEC Rated) <u>will</u> <u>not</u> <u>be</u> <u>accepted</u> even if they were to show equivalent NEMA ratings.

B. Starters shall be full voltage non-reversing (FVNR), full voltage reversing (FVR), as indicated on the PLANS. Additionally, each coil of all starters (of any NEMA size) shall be furnished with manufacturer's Transient Suppression Module of size corresponding to the NEMA rating of the respective starter.

C. Furnish one additional Normally Open (N.O.) and one additional Normally Closed (N.C.) auxiliary motor starter spare contacts over the number required by the schematic diagrams.

D. Overload relays shall be standard class 20, ambient compensated, manually reset by push-button located on front of the compartment door. Refer to PLANS for control circuit wiring of the overload relay contacts.

2.04 CONTROL POWER TRANSFORMERS AND MISCELLANEOUS ACCESSORIES.

A. Each starter shall be furnished with control power transformer, 120 volt fused and grounded secondary. Each transformer shall be adequately sized to drive all control components of its respective equipment shown on the control schematics in addition to the space heater of the respective equipment (motor). Minimum acceptable control transformer size shall be 200VA. Primary side of the transformer shall be fused.

B. In each Combination Motor Starter unit, furnish and install one single pole fuse block with fuse and switch for each motor space heater. Wired to secondary side of control transformer as shown on the schematic diagrams.

C. Indicating lights shall be NEMA Style, full size 30-millimeter (30mm), Transformer Type Light Emitted Diode (LED), NEMA Style 4/4X/13, corrosion resistant, oil tight/watertight, full size, push to test type, rated at 120VAC, with legend plate marked as shown on the PLANS. Lens color shall be as shown on the PLANS. Refer to PLANS control schematics and details for the exact color requirements. Pilot lights shall be as manufactured by Allen-Bradley Bulletin 800H NEMA Type NEMA 4/4X/13, corrosion resistant, oil tight/watertight, or approved equal. Miniature size pilot lights will not be accepted.

D. Control relays shall be provided as required by the schematic diagrams. Relays shall be 600v Heavy-Duty industrial type with 120 volt coils. Minimum contact rating shall be 10A, continuous, at 120 volts AC. Furnish each relay with one additional Normally Open (N.O.)

and one additional Normally Closed (N.C.) contacts over the number required by the schematic diagrams. Relays shall be furnished with visual mechanical latch-unlatch indicators. Additionally, coil of each relay shall be furnished with Relay Manufacturer's Transient Suppression Module. Relays shall be Allen Bradley Bulletin 700-P, or approved equal. So called "International" and IEC rated relays will not be accepted. All relays shall be standard NEMA size.

E. Timing Relays: Time delay relays shall be the solid state type, with multi-time ranges and multi-function modes. Minimum relay contract rating shall be 10 amps, continuous, at 120 VAC. Timing relays shall be Dayton model No. 6A855 complete with Dayton Socket No.6X156, or approved equal.

F. Pushbuttons and Selector Switches shall be NEMA Style, full size 30-millimeter (30mm), NEMA 4/4X/13, corrosion resistant, oil tight/watertight, full size, and complete with legend plate marked as shown on the PLANS. Selector switches and pushbutton contacts shall be rated 10 amps at 120 VAC. Selector switches and pushbutton shall be as manufactured by Allen-Bradley Bulletin 800H NEMA Type NEMA 4/4X/13, corrosion resistant, oil tight/watertight, or approved equal. Miniature size station will not be accepted.

PART 3 - EXECUTION

3.01 FACTORY INSPECTION AND TEST

A. The Combination Motor Starters shall be completely assembled, wired, and adjusted at the factory and shall be given the manufacturer's routine shop test and any other additional operational test to insure the workability and reliable operation of the equipment.

B. Factory test equipment and test methods shall conform with the latest applicable requirements of ANSI, IEEE, UL, and NEMA standards, and shall be subject to the Engineer's approval.

3.02 FIELD INSTALLATION (BY CONTRACTOR)

A. Field installed wiring to Combination Motor Starters shall be neatly bundled with nylon wire ties and supported. Control wiring shall be bundled separately from power wiring.

B. All field wiring shall be tagged and coded with an identification number. Coding shall be typed on a slip-on tube applied to each end of the wire. The marking shall be a permanent, non-smearing, solvent-resistant type and per the requirements of Section 16200 "Wiring (600 Volts and Below)". Tags must be typed. Handwritten tags will not be accepted. Characters size shall be minimum of 1/8" in height.

C. Install Combination Motor Starter units where the top of each unit is no higher than 5-feet-6-inches above the finished floor elevation, unless otherwise noted on the PLANS or the unit is equipped with a free-standing enclosure.

D. Use "Unistrut" or approved equal Stainless Steel channel supports and fittings for installation, i.e., do not mount/support any Combination Motor Starter units directly to

building walls. Gauge of the Stainless Steel channel shall be in compliance to the requirements of Section 16150 “Raceways, Fittings and Supports” for Support of Electrical Equipments and Raceways. However all fastening hardware, fittings, supports, base posts, clamps, channel nuts, framing system, etc. shall be fabricated with 316 stainless steel,. Use split ring lock washers with all fastening hardware. Also refer to details shown on the PLANS.

3.03 FIELD TEST AND CHECKS

A. The following minimum test and checks shall be made before energizing the Combination Motor Starters:

1. Verify heater circuits are operational.

2. Submit documentation of all tests outlined above. Include all test documentation data in operation and maintenance manuals.

3. Check the entire equipment control circuitry and/or logic within the Combination Motor Starters and verify its reliable and accurate operation per the control schematics and/or per the requirements of the Control Systems Contractor.

3.04 EQUIPMENT PROTECTION AND RESTORATION

A. Clean and vacuum clean all interior of the equipment.

B. Touch-up and restore damaged surfaces to factory finish.

C. After all connections have been made, the Contractor shall spray all terminals, terminal blocks, starters (with contacts closed) with a moisture repelling chemical such as provided by CRC or Dow Chemical Corporation, or approved equal.

D. Notify the Engineer 24 hours prior to intent to spray each Combination Motor Starter. If no such notification is made it will be presumed that moisture proofing has not been accomplished.

E. Install overload relay heaters based on actual motor nameplate current. Set overload relay settings at maximum values permitted by the NEC 430-32.

F. Verify proper rotation of each motor load.

3.05 TRAINING

A. Provide training session for owner’s representatives for One (1) FULL normal workday at the job-site location and/or at a location determined by the owner. If training is conducted in less than the time required by these specifications, the remaining time shall be utilized at the discretion of the Owner.

B. The training session shall be conducted by the Combination Motor Starter unit manufacturer's non-sales-type technical representative, who performed the field installation and start-up/setting/adjustment services.

C. At minimum, the training session shall include:

1. Operation and maintenance procedure for the equipment and all components installed within the Combination Motor Starter units.

2. Factory contact persons phone numbers, persons names, ordering procedures and procedures to follow to obtain meaningful results from the factory.

3.06 MEASUREMENT AND PAYMENT

A. No separate measurement or payment for work performed under this Section. All costs are included in the Base Bid.

END OF SECTION

SECTION 16450

600 VOLT AND BELOW DRY TYPE TRANSFORMERS

PART 1 - GENERAL

1.01 SCOPE

Furnish and install dry type transformers of type required and where indicated on the Plans. Comply with this Specification.

1.02 SUBMITTALS

A. Submit shop drawings in accordance with Section 01300 of the Contract Specifications.

B. Submit Operations and Maintenance Manuals (O&M) in accordance with Section 01730 of the Contract Specifications. O&M Manuals shall include copies of the approved shop drawings, factory and on-site/field test data.

1.03 DELIVERY, STORAGE AND HANDLING

Deliver, receive, unload and handle equipment by suitable methods. Inspect for damage before accepting shipment. Wrap in protective plastic wrapping and store in humidity controlled environment. Use heat lamps as necessary to prevent condensation.

1.04 ACCEPTABLE MANUFACTURER

A. General Use (Power & Lighting) Dry-Type Ventilated Isolation Transformers for indoor installation inside the environmentally and climate controlled Substation No. 1 Building, transformers shall be:

1. General Use (Power & Lighting) Dry-Type Ventilated Isolation Transformers shall be Watchdog Premium Quality units manufactured by Sorgel (Square D) class 7430, or approved equal.

B. Ultra-Isolator, Highly Shielded and Noise and Transient Voltage Suppressing Transformers: shall be as manufactured by "Eaton" Power-Suppress T7 Series 30 Ultra-Isolation Transformers with "K" Factor 13 Rating (with electrostatic shielding) and with Noise Filters, Transient Voltage Suppressors and all other specified accessories, or approved equal.

PART 2 - PRODUCT

2.01 GENERAL AND BASIC REQUIREMENTS FOR ALL 600 VOLT AND BELOW DRY TYPE TRANSFORMERS

A. Type:

Manufacturer's premium quality dry type transformers. Primary and secondary voltage ratings, and, KVA ratings to be as shown on the PLANS. All windings shall be copper. Transformers shall be of ventilated type.

B. Taps:

Furnish with four (4) 2-1/2% full capacity primary, two (2) above and two (2) below rated primary voltage.

C. Core and coils:

Continuous wound core impregnated with non-hygroscopic, thermosetting varnish. Core to be of high grade, non-aging silicon steel with high magnetic permeability. Core and coil bolted to base of enclosure but isolated from it by rubber vibration absorbing mounts.

D. Grounding:

Core is to be visibly grounded to enclosure by means of a flexible grounding conductor sized per NEMA, IEEE and ANSI standards.

E. Sound levels:

Guaranteed not to exceed the following:

Transformer KVA Range	Sound Level
15 to 50KVA	45dB
51 to 150KVA	50dB
151 to 300KVA	55dB

F. All transformers shall be U.L. listed and certified and carry the U.L. label.

2.02 GENERAL USE (POWER & LIGHTING) VENTILATED DRY TYPE ISOLATION TRANSFORMERS

A. Transformers shall be of the dry type suitable for indoor installation. Comply with all requirements/specifications outlined in paragraph 2.01, above (Basic and General Requirements for All 600 volt and Below Dry Type Transformers). Transformers shall meet NEMA TP-1 efficiency requirements.

B. Temperature Rise:

Premium quality, 80 degrees C. above a 40 degree C. ambient, capable of carrying a 30% continuous overload without exceeding a 150 degree C. rise in a 40 degree C. ambient. All insulating materials shall be in accordance with NEMA ST20 standards for a 220 degree C. U.L. component recognized insulation system.

C. Enclosure:

Heavy gauge sheet steel with ventilation openings designed in accordance with U.L., NEMA and the N.E.C. Phosphatized, primed and finished with ANSI#61 gray baked enamel.

2.03 CONTROL AND INSTRUMENT POWER ULTRA-ISOLATOR, HIGHLY SHIELDED AND NOISE SUPPRESSION TRANSFORMERS

A. General:

Transformers shall be of the dry type suitable for indoor installation. Comply with all specifications requirements outlined in paragraph 2.01, above (Basic and General Requirements for All Dry Type Transformers) in addition to the requirement specified in this subsection 2.03. Note: Requirements hereinafter specified take precedence over the requirements outlined in subsection 2.01 above.

B. Temperature Rise:

80 degrees C. above a 40 degree C. ambient, capable of carrying a 30% continuous overload without exceeding a 150 degree C. rise in a 40 degree C. ambient. All insulating materials shall be in accordance with NEMA ST20 standards for a 220 degree Celsius U.L. component recognized insulation system.

C. Enclosure:

Heavy gauge sheet steel with ventilation openings designed in accordance with U.L., NEMA and the N.E.C. Phosphatized, primed and finished with gray baked enamel.

D. Frequency:

The ultra-isolation transformer shall operate within a frequency range of 57 Hz to 63 Hz (for 60 Hz models).

E. Input Voltage Range:

The ultra-isolation transformer shall operate within an input voltage range of +10% of nominal.

F. Load Regulation:

The load regulation shall be 3.5% or less from no load to full load at unity power factor.

G. Overload Capacity:

The ultra-isolation transformer shall withstand overloads of 500% for one cycle with no adverse effects.

H. Harmonic Distortion:

The ultra-isolation transformer shall add no more than 1% total harmonic distortion to the output waveform.

I. Efficiency:

The ultra-isolation transform shall have a minimum energy efficiency of 95% at all load levels.

J. Dielectric Strength:

The ultra-isolation transformer shall have a dielectric strength of 2500 VAC from shields to core.

K. Insulation Resistance:

The ultra-isolation transformer shall have an insulation resistance of 1000 megohms minimum from windings to core measured at 50 VPC.

L. Electromagnetic Noise:

The ultra-isolation transformer shall produce no more than 0.1 gauss of electromagnetic noise measured at 18 inches from the transformer.

M. Audible Noise Attenuation:

The ultra-isolation transformer shall produce less than 50 dBA audible noise measured at a distance of 3 feet.

N. Common-Mode Noise Attenuation:

The ultra-isolation transformer shall be available with any one of four common-mode noise attenuation specifications:

40 million to 1 (152 dB minimum at .00025 pF)
20 million to 1 (146 dB minimum at .0005 pF)
10 million to 1 (140 dB minimum at .001 pF)
2 million to 1 (126 dB minimum at .005 pF)

O. Normal-Mode Noise Attenuation:

The ultra-isolation transformer shall provide normal-mode noise attenuation of -3 dB at 600 Hz, increasing at a rate of -20 dB per decade to -60 dB at 100 kHZ.

P. Warranty:

Five (5) year manufacturer's full warranty (non-prorated type) after owner acceptance and after the final completion date of the project.

Q. Isolation:

All windings are to be electrically isolated from each other.

R. Shielding:

100% electrostatic shielding. A minimum of one turn of thin sheet copper extending over the full width and height of the transformer windings (shielding shall be installed over the insulation layer applied over the windings). Additionally, an additional layer of insulation must be applied over the electrostatic shielding layer of each winding. Shields must be connected to terminal inside the transformer layer. Shield terminal/lug shall be electrically isolated from the transformer frame/housing/enclosure.

S. "K" Factor Rating:

The transformer shall be U.L. Listed having a "K" factor rating of 13 and suitable to handle and support an equivalent of 100% intense non-linear and single phase load application.

T. Transient Voltage Surge Suppression:

Primary across the lines and Secondary filters to optimum surge suppression and protection for the loads served by the transformer.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install at the locations shown on the PLANS.

B. Provide 1'-0" separation from the wall for all transformers. Also refer to PLANS for arrangements.

C. Install floor mounted transformers on 1" thick Korfund vibration isolating pads as detailed on the PLANS.

D. Make grounding connections as required by the N.E.C. and as shown on the PLANS.

E. Ground all shields of transformers (electrically isolated from body ground) as also indicated on the PLANS.

F. Identification:

Give transformer characteristics on 3-ply phenolic "Black-White-Black" laminated nameplate with 1/2" lettering. The nameplate shall identify the name of the load served by the transformer, primary voltage rating, secondary voltage ratings, KVA rating, phase, wire, primary and secondary winding configuration, and transformer type.

G. Refer to specification Section 16200 "Wiring (600 Volts and Below)" for special and specific field wiring termination requirements.

3.02 TESTS AND INSPECTIONS

A. Test transformers in accordance with the provisions of Section 16800 "Calibration, Testing and Setting". Additionally, megger test (minimum 1000 megohms) primary windings to shield, secondary windings to shield, in addition to primary to ground and secondary to ground.

B. All test results (including factory test) shall be certified, including the guaranteed maximum effective primary to secondary capacitance.

3.03 MEASUREMENT AND PAYMENT

A. No separate measurement or payment for work performed under this Section. All costs are included in the Base Bid.

END OF SECTION

SECTION 16480

OVER 600 VOLTS DRY TYPE TRANSFORMERS FOR OUTDOOR SERVICE

PART 1 - GENERAL

1.01 SCOPE

A. Furnish and install two Unit Substation Dry-Type Transformers at the proposed Substation No. 1 for primary voltage step-down from 12470 volts to 480 volts. The Substation No. 1 unit substation transformers are identified on the PLANS as SUB1-XFMR-CPT100 and SUB1-XFMR-CPT200 and shall hereinafter be referred to as the "SUB1XFMR". Provide the SUB1XFMR complete from the incoming line terminals to the outgoing line terminals as specified herein. Also refer to the PLANS.

B. Each transformer shall be the manufacturer's premium quality, encapsulated and sealed Unit Substation Dry-Type Transformer mounted in a suitable outdoor enclosure with side-wall mounted primary and secondary terminations.

C. This specification covers the electrical characteristics and mechanical features of three-phase, 60 Hertz, delta-wye connected, Dry-type transformers, rated 75 KVA through 5,000 KVA @ 80° C temperature rise above ambient.

D. Comply with the requirements of the Contract Documents.

1.02 RELATED REQUIREMENTS

A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.

B. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work.

C. The PLANS designate the size, rating, and other requirements of the Unit Substation Dry Type Transformers.

D. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

1.03 QUALITY ASSURANCE

A. Equipment is to be designed, built and tested in accordance with the latest revisions of all applicable standards of NEMA, IEEE, ANSI and U.L.

B. In addition to the tests required by the standards, each unit is to be given a standard production line impulse test.

C. Comply with the requirements of NEMA, OSHA, NEC and all building codes. Design, construct, assemble and test in accordance with AISC, AISI, ASTM, NEMA, IEEE, U.L. and ANSI standards

D. Standardization: All like equipment to be the product of one manufacturer.

E. Testing: Shop test transformers in accordance with ANSI test code for transformers, including:

1. Ratio test for winding and taps.

2. No load loss, load losses, efficiency, regulation, impedance, resistance, and reactance.

3. Impulse and induced potential test.

4. Furnish certified copies of the test results for comment prior to shipment. Format and number of copies shall be in accordance with the requirements of Section 01300 and Section 01730 of the Contract Specifications.

1.04 ACCEPTABLE MANUFACTURERS

A. The manufacturer of the SUB1XFMR assembly shall be the same manufacturer of major transformer components within the respective assembly.

B. Furnish manufacturer's premium quality units constructed to withstand adverse environments. Units shall be as manufactured by Square D, Hammond Power Solutions, Inc., or approved equal.

1.05 MANUFACTURER'S SERVICE

A. Technical Services: Furnish services of a technical representative of the manufacturer to inspect the equipment after installation and to supervise initial operation. Include time to correct any defects.

B. Report: Furnish a written report certifying that the equipment was checked and found to be installed in accordance with manufacturer's recommendation and operated properly. Format and quantity of the reports shall be per the requirements of Section 01300 of the Contract Specifications.

C. In addition to the requirements of this Subsection, fuses shall also be furnished by the manufacturer based on the results of the short circuit and coordination study. Additionally, the Manufacturer will select a variety of protective devices having the characteristics that are most suitable for the system in providing proper protection and coordination. The selection of the fuse will be based on coordination and short circuit studies performed in compliance with Section 16044 of the Specifications, paragraph 1.09 "Special Manufacturer's Services".

The final selection will be based on the manufacturer's submittal of a variety of fuse curves for the OWNER to select from. The Manufacturer shall furnish the protective device of the appropriate characteristics selected by the OWNER that shall be the most suitable for the proper protection and coordination of the system at No Additional Cost to the OWNER. Provide the OWNER with test report certified by the manufacturer. Include a record of all settings. Format and quantity of reports shall be per the requirements of Section 01300 and Section 01730 of the Specifications.

D. Any problems encountered with the operation of equipment, parts, components, etc. installed shall be repaired/remedied by the manufacturer's technical representative.

1.06 SUBMITTALS

A. Shop Drawings and Product Data: Submit complete shop drawings and engineering data for review and comment in accordance with this Section and the contract documents. Include the following:

1. Dimensional drawings including plan view and elevations.

2. Bill of materials.

3. Transformer nameplate data, weight, and product data.

4. Wiring diagrams.

B. Factory certification report: Submit a manufacturer's certified test reports on each transformer covering exciting current, no load, full load losses and impedance, and noise level test data (dB: decibels). Typical data from other previously tested transformers will not be accepted. The factory certification report shall be submitted to, and accepted by the Owner prior to shipment of the transformers to the project site. Format and quantity of reports shall be per the requirements of Section 01300 of the Contract Specifications.

C. Operation and Maintenance Manuals: Submit Operation and Maintenance Manuals in accordance with this section and Section 01730 of the Contract Specifications. Include approved shop drawings.

1.07 RECEIVING AND STORING

A. Unload and handle equipment by suitable methods that are recommended and approved by the manufacturer of the equipment.

B. Carefully inspect the unit upon its arrival to the job site. Note any deficiencies observed.

C. Protect unit with plastic covering and use heat lamps (or appropriate heaters as recommended by the manufacturer) to prevent condensation.

D. Examine unit for indication of moisture. Take appropriate measures to dry out transformer if moisture is found.

PART 2 - PRODUCTS

2.01 RATINGS

A. The installed transformer, after manufacturing of the transformer, shall conform to the ratings provided in the following table:

Rating Category	Value
Frequency	60 Hertz
KVA	As indicated on the plans
Impedance	7.5%
Primary Voltage	12470 volts, delta connected
Secondary Voltage	480/277 volts, grounded wye connected
Primary BIL	95 kV; Insulation class: 15 kV
Secondary BIL	30 kV; Insulation class: 1.2 kV
Maximum Sound Level	66 dB (including forced air fan cooling system)

2.02 HIGH VOLTAGE TAPS

A. The transformer shall have two (2) 2-1/2% taps above and two (2) 2-1/2% taps below the rated voltage.

2.03 RATED VOLTAGE.TEMPERATURE RISE

A. Transformers shall have a maximum temperature rise of 80°C above a 40°C maximum ambient

2.04 TESTING

A. Transformers shall be manufactured and tested in accordance with IEEE standards C57.12.01, C57.12.91, C57.12.50, and C57.12.51.

2.05 CONSTRUCTION

A. General:

1. The transformer(s) shall be combination self-cooled and fan-cooled (when called for by a built-in thermostat). Transformer shall be suitable for mounting on a pad and shall comply with the latest applicable standards. Transformers shall be equipped with forced-air cooling system (electric operated fans). Fan motor and fan controls shall operate off the secondary voltage of the transformers which shall be located inside the transformer housing. The forced air cooling shall be regulated automatically by sensors placed in the low voltage air ducts. As minimum, the forced cooling shall include:

    a. Thermal sensors

    b. Electric operated fans

    c. Control wiring, terminals, etc.

    d. Temperature controller with test switch

    e. Current limiting fuses

    f. Indicating lights

    g. Visual and audible alarm

    h. Alarm Silencing relay and pushbutton operated control switches

    i. Automatic fan exerciser functionality

    j. Additional requirements as shown on the PLANS.

2. The transformer shall be suited for harsh environments where chemical fumes, dust, or vibration may be present.

B. Core and Coil Construction:

1. The transformers coils shall be designed to maintain their nameplate KVA rating throughout the temperature range.

2. Transformer coils shall be cast coil construction where the entirety of the primary and secondary coils are entirely immersed and fully sealed within epoxy resin material under vacuum in a mold.

    a. High and low voltage windings shall each be separately cast as one rigid tubular coil, and arranged coaxially. Each cast coil shall use a mineral-filled epoxy reinforced with fiberglass mat, and cast to provide complete, void-free resin impregnation throughout the entire insulation system. The coil supports shall maintain constant pressure during thermal expansion and contraction of the coils. There shall be no rigid mechanical connection between high and low voltage coils.

    b. The coils are to be cast in epoxy in a mold, using a computer-controlled mixing and casting process that ensures the absence of voids. The epoxy used in the casting process shall be mineral-filled epoxy that is Underwriters Laboratories (UL) approved. The mineral filling shall enhance the pure epoxy to increase its thermal

conductivity, mechanical strength, arc resistance, and adhesion to the conductor, and change its coefficient of thermal expansion to be close to that of the conductor material.

c. The windings shall be fiberglass reinforced to provide additional mechanical strength.

d. Each winding shall be partial-discharged tested using induced voltage to ensure that it is void-free. The transformer windings must be free of partial discharge up to at least 1.2 times the rated line-to-ground voltage. All coils shall be subjected to a partial discharge test to verify its partial discharge.

3. The windings must not absorb moisture and shall be suitable for both storage and operation in adverse environments, including indefinite storage in 100% humidity at temperatures from -30 °C to + 50 °C and shall be capable of immediately being switched on after such storage without need for any predrying.

4. All cores shall be constructed of high grade, grain oriented, non-aging silicon steel with high magnetic permeability and low hysteresis and eddy current losses. Core laminations shall be miter cut at the core corners. The laminations shall be clamped together utilizing insulated bolts through the core laminations. The core shall be manufactured to ensure optimum performance and minimal sound levels. Magnetic flux densities shall be kept well below the saturation point.

5. Provision shall be made to completely isolate the core and coil from the enclosure. There shall be no metal-to-metal contact. Rubber vibration isolation pads shall be installed by the manufacturer between the core and coil and the enclosure base. The core shall be visibly grounded to the ground bus or ground pad by means of a flexible grounding conductor sized in accordance with applicable NEC standards.

C. Core and Coil Assembly:

1. The core and coil, after assembly, shall be mounted in a rigid steel frame, constructed in such a way as to hold the coil in a rigid position within the core window. No wood other than the processed hardwood maple shall be used in core-coil assembly and then only in proper ratio with other materials.

2.06 ENCLOSURE

A. Dry-type transformers shall be mounted in a heavy gauge Type 316 Stainless Steel enclosure. Enclosures shall have a smooth, non-brushed finish. The enclosure shall have ventilated openings to provide for the circulation of external air through the enclosure. All ventilating openings shall be in accordance with NEMA and National Electrical Code (N.E.C.) Standards for ventilated enclosures. Provide enclosure with special ventilating grills that restrict the passage of rain and prevent the entrance of rodents. The enclosure shall be of NEMA Type 3R construction rated for Outdoor use.

B. The enclosure base shall be provided with lifting devices and jacking pads designed to be flush with the enclosure.

C. Access to the transformer section shall be through removable panels.

D. Transformer finish shall be manufacturer's standard.

E. Transformer shall be front accessible.

2.07 SUB1XFMR HIGH AND LOW VOLTAGE TERMINALS:

A. The bushings and terminals shall be located in accordance with ANSI C57.12.26.

B. The transformer shall be provided with externally clamped, porcelain bushings. High voltage bushings shall be provided with a two-hole spade connector. Low voltage bushings shall coordinate with the field wiring termination requirements as shown on the PLANS.

C. The transformer shall be equipped with high voltage air terminal compartment and a low voltage air terminal compartment. The compartments shall have the full height and depth of the transformer enclosure and be a part of the entire transformer assembly. Low voltage terminal compartment depth shall be no less than 30 inches. Coordinate with the requirements of the PLANS.

D. The low voltage neutral bushing shall be an insulated bushing with a removable external ground connection factory bonded to the grounding wire inside the secondary low voltage air terminal compartment. The ground strap shall be adequate to carry the fault current based on the rating of the transformer.

E. Furnish multi-ratio current transformers (C.T.'s) for differential relaying on the low voltage bushings. Install a multi-ratio current transformer per phase. Connect the secondary wiring of the C.T.'s to a shorting terminal block (one per phase). Mount shorting terminal blocks in a NEMA-4X watertight and corrosion resistant metal cabinet. Cabinet shall be furnished with hinged and lockable door, attach cabinet to the frame of the main power transformer.

F. SUB1XFMR high and low voltage terminals shall be located as follows:

Transformer Name (as Shown on the PLANS)	Terminal Location (When Facing the Transformer Front)	
	High Voltage	Low Voltage
SUB1-XFMR-CPT100	Left	Right
SUB1-XFMR-CPT200	Left	Right

2.08 NAMEPLATE

A. The instruction nameplate shall be located at convenient spot on the inside of the low voltage cable termination area (within the transformer) and shall be readable with cables in place. An additional nameplate shall be located on the exterior of the low voltage cable termination section (located on face of the transformer enclosure panels).

B. The nameplate shall be made of a corrosion resistant material.

C. Install a phenolic nameplate on the exterior of the high voltage Section (cable termination area). The nameplate shall have 2" high, white letters on black face, fastened to the doors by stainless steel screws. The nameplate shall indicate the name as shown on the PLANS.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Construct a concrete pad for each unit, as detailed on the PLANS, at the locations indicated. Follow manufacturer's instructions and approved practice for installation of the transformer.

B. Level and mount with leveling and anchoring bolts as recommended by the manufacturer.

3.02 TESTING AND PLACING IN SERVICE

A. Energize the transformers and place them into service with representative of Austin Water Utility witnessing the same. Coordinate start-up with other phases of construction.

B. Before placing into service, megger test primary and secondary windings per the requirements of Section 16800.

C. Before placing into service, ensure transformer is connected for proper operation at the required voltage and on the proper tap.

3.03 MEASUREMENT AND PAYMENT

A. No separate measurement or payment for work performed under this Section. All costs are included in the Base Bid.

END OF SECTION

SECTION 16500

PANELBOARDS

PART 1 - GENERAL

1.01 SCOPE

A. Furnish and install Alternating Current "AC" Lighting Panelboards, Power Distribution Panelboards, and Surge Protective Devices where indiciated on the PLANS.

B. Furnish and install Direct Current "DC" Power Distribution Panelboards, where indicated on the PLANS.

1.02 SUBMITTALS

A. Submit Shop Drawings in accordance with Section 01300 of the Contract Specifications. Include panelboard dimensions, ratings, branch circuit breaker schedules and main circuit breakers size.

B. Submit Operations and Maintenance Manuals (O&M) in accordance with Section 01730 of the Contract Specifications. O&M Manuals shall include copies of the approved shop drawings, and on-site/field test data.

C. Deliver, receive, unload and handle equipment by suitable methods. Store in humidity controlled environment in original packaging, or, in protective plastic wrapping.

1.03 QUALITY ASSURANCE

A. Panelboards shall be U.L labeled "U.L. 67, U.L 508" and meeting Fed. Spec. WP-115a, Type 1, Class 1. Breakers to meet Fed. Spec. WC-3756.

B. 208/120 volts "AC", 3-phase, 4-wire Panelboards - Cutler-Hammer Corporation Type POW-R-Line 3a with specified accessories. Approved equal Panelboards manufactured by Square-D Company or General Electric are acceptable as equals.

C. 480/277 volts "AC", 3-phase, 4-wire Power Distribution Class Panelboards - Cutler-Hammer Corporation Type 4B with specified accessories. Approved equal Panelboards manufactured by Square-D Company or General Electric are acceptable as equals.

D. 250/125 volts "DC", One(1)/Two(2) phases, 3-wire (including ground) Power Distribution Class Panelboards - Cutler-Hammer Corporation Type 4B with specified accessories. Approved equal Panelboards manufactured by Square-D Company or General Electric are acceptable as equals.

PART 2 - PRODUCTS

2.01 BUSSING ASSEMBLY AND TEMPERATURE RISE

A. Panelboard bus structure and main lugs or main breaker to have current ratings as shown on the PLANS. Such ratings to be established by heat rise tests with maximum hot spot temperature on any connector or bus bar not to exceed 50 degrees C rise above any ambient of 40 degrees C. All bus shall be tin-plated copper, distributed phase sequence type, and extending the full length of the panelboard. Circuit numbering to be such that odd numbered circuits are on the left and even numbered on the right facing the front of the panel.

B. The minimum RMS symmetrical short circuit current rating of the buses shall be as indicated on the one-line diagram drawings. However, the minimum RMS symmetrical short circuit current rating of the bus shall not be less than the highest symmetrical short circuit rating of the main and feeder circuit breakers installed in the Panelboard and at the rated voltage of the Panelboard.

C. 250/125 Volts "DC" Power Distribution Panelboards shall have one bus dedicated to Positive (+) charge carrying while the other shall be dedicated to Negative (-) charge carrying.

D. Provide lugs in 250/125 Volts "DC" Power Distribution Panelboards as required for termination of field wiring. Sizes shall be as required by the PLANS. At a minimum, furnish and install 10 lugs for each bus as follows:

1. Phase bus lug termination range: #4/0 AWG to #1000 kCMIL

2. Ground bus lug termination range: #8 AWG to #4/0 AWG.

2.02 CIRCUIT BREAKERS

A. Circuit breakers to be single pole, two pole or three pole as shown. All breakers to be quick-make, quick-break thermal magnetic molded case bolt-on type, with inverse time thermal trip and instantaneous time magnetic trip. Multi-pole breakers to be common trip with a single trip handle; handle ties are NOT TO BE USED. Provide overload tripping elements in each pole. A tripped condition to be indicated by the breaker assuming a neutral position between "ON" and "OFF".

B. Provide circuit breakers complete with rating plugs and other accessories as required for proper operation of circuit breakers.

C. Provide circuit breakers with auxiliary contacts rated for 120 volts A.C., where shown on the PLANS. Contacts shall satisfy the requirements of the PLANS.

D. Panelboards shall be provided with high interrupting capacity or current limiter type breakers where necessary to withstand the available short circuit or limit it to a value which the downstream breakers can withstand.

E. Panelboards shall be provided with ground fault circuit interrupter (GFCI) or ground fault equipment protection (GFEP) type breakers where indicated on the PLANS.

F. Circuit breakers to be equipped with individually insulated, braced and protected connectors. Affix large, permanent, individual circuit numbers to each breaker in a uniform position.

G. Circuit breakers for lighting circuit protection are not to be larger than 20 amperes when serving fluorescent or medium base and mogul base incandescent fixtures.

H. 250/125 Volts "DC" Power Distribution Panel board circuit breakers shall operate continuously when operating/running current is equal to 100% of the long time trip setting (or frame rating, as applicable) of the breakers and shall be suitable for reverse feeding.

I. Circuit breaker interrupting ratings and type to be as follows:

1. 208/120 Volts "AC" Lighting Panelboards – Minimum U.L. listed Current Interrupting rating of 10,000 A..I.C. symmetrical @ 208 volts, unless shown otherwise on the PLANS. Cutler-Hammer Corporation, Type FD/HFD, or approved equal by General Electric Company "G.E", Square-D Company.

2. 480/277 Volts "AC" Power Distribution Class Panelboards – Minimum U.L listed Symmetrical Current Interrupting rating (A.I.C. rating) @ 480 Volts shall be as shown and required by the PLANS. Cutler-Hammer Corporation, Type FDC, or approved equal by General Electric Company "G.E.", Square-D Company. Provide current limiting circuit breakers where shown on the PLANS. The LOAD-SIDE of the current limiting type circuit breakers shall have a reduced (limit) symmetrical fault current output (maximum let through symmetrical short circuit current) that is considerably less than the symmetrical short circuit rating of the BUS-SIDE of the respective/same current limiting circuit breaker. The required maximum let-through symmetrical short circuit current expected from each current limiting circuit breaker is shown on the PLANS. Additionally, the symmetrical short circuit current rating of the BUS-SIDE of each current limiting circuit breaker is also shown on the PLANS.

3. 250/125 Volts "DC" Power Distribution Panelboards – Minimum U.L listed Symmetrical Current Interrupting rating AND based on NEMA test procedure rating (A.I.C. rating) @ 250 Volts DC shall be as shown and required by the PLANS. Cutler-Hammer Corporation "TRI-PAC Series" Types FB-P, LA-P, and NB-P (as per the required continuous current rating of the circuit breakers), or approved equal by General Electric Company "G.E.", Square-D Company. Provide current limiting circuit breakers where shown on the PLANS. The LOAD-SIDE of the current limiting type circuit breakers shall have a reduced (limit) symmetrical fault current output (maximum let through symmetrical short circuit current) that is considerably less than the symmetrical short circuit rating of the BUS-SIDE of the respective/same current limiting circuit breaker. The required maximum let-through symmetrical short circuit current expected from each current limiting circuit breaker is shown on the PLANS. Additionally, the symmetrical short circuit current rating of the BUS-SIDE of each current limiting circuit breaker is also shown on the PLANS.

J. Padlock attachments shall be provided for circuit breakers where shown on the PLANS.

2.03 INTEGRATED EQUIPMENT RATING

A. Each panelboard, as a complete unit, to have a rating equal to or greater than the integrated equipment rating shown on the PLANS. Such rating to be established by test with the circuit breakers mounted on the panelboard. The short circuit tests on the circuit breaker and on the panelboard structure shall be made simultaneously by connecting the fault of each panelboard breaker with the panelboard connected to its rated voltage source.

2.04 CABINET

A. Panelboard assembly installed indoors inside the environmentally and climate controlled SUBSTATION NO. 1 BUILDING, shall be enclosed in a NEMA-12 gasketed cabinet, the rigidity and gauge of steel to be as specified in U.L. Standard 50 for cabinets. All Panelboard doors shall be door-in-door arrangement. The inner door shall be hinged to allow access to the circuit breakers; and the outer door shall also be hinged to allow access to the wireway for maintenance efficiency. The inner door of panelboards shall not be KEYED/LOCKABLE. The outer door of panelboards SHALL NOT BE KEYED/LOCKABLE but shall be BOLTED with HEX-TYPE 316-Stainless Steel Bolts. No locks shall be used on inner doors of panelboards. A circuit directory in a metal frame with clear plastic covering shall be provided on the inside of each door. A directory card shall be typed to identify the load served by each circuit. Spare breakers shall be noted in pencil, however. NEMA-12 panelboards shall have ANSI #61 Gray finish.

2.05 SAFETY BARRIERS

A. The panelboard interior assembly to be dead front with panelboard front removed. Main lugs or main breaker to be barriered on five sides. The barrier in front of the main lugs to be hinged to a fixed part of the interior. The end of the bus structure opposite the mains to be barriered.

2.06 GROUNDING PROVISIONS

A. Each panelboard shall have a grounding bar for connecting equipment grounds. Ground bar shall not be connected to the neutral bar. In addition to the equipment ground bar, where called for in the following subsection, furnish a second isolated ground bar in panelboard which shall be electrically isolated from the panelboard cabinet/enclosure by 600 volt isolators. Isolated ground bar shall have the same continuous current rating as the phase bussing (bus rating) of the panelboard.

1. Furnish and install an isolated ground bar in the following panelboards:

    a. SUB1-PDB-001

    b. SUB1-PDP-DC01

    c. SUB1-PDP-002

    d. SUB1-LP-002

B. 250/125 Volts "DC" Power Distribution Panel board ground buses shall have the current rating of ground bus equivalent to the phase bus current rating. Ground bus shall be mounted on stand-off isolators.

2.07 LABEL

A. All panelboards to bear the U.L. label and meet Fed. Spec. W-LP-115a. Circuit breakers to meet Fed. Spec. W-C357b.

2.08 SPARES

A. Provide a minimum of 20% spares on all panelboards and/or as shown on panel schedules on the PLANS.

2.09 SURGE PROTECTIVE DEVICES

A. Furnish and install Surge Protective Devices (SPD) where required by the PLANS. Each SPD shall have the following features:

1. Number of phases and system configuration (delta, wye grounded) to match and fully protect the bus to which the SPD is connected.

2. SPD shall be tested with the ANSI/IEEE Category C high exposure waveform of 10 kA for 8 x 20 microseconds, at minimum. Visual indication of SPD status.

3. Visual indication of SPD status.

4. Surge counter.

5. Provide dry contact failure status output contact. Contact shall be rated for 120 volts A.C. and shall satisfy the requirements of the PLANS.

6. Compliance with UL 1449 and UL 1283 standards.

7. 20 year minimum warranty.

8. SPD surge current withstand ratings shall be as follows:

Panelboard Voltage	Minimum Current Withstand rating (Ampere per phase)	Minimum Current Withstand rating (Ampere per mode)
208/120 Volts AC	150 kA	75 kA
480/277 Volts AC	240 kA	120 kA

B. Enclosure:

1. SPD located indoors in environmentally controlled rooms: NEMA 12.

2. SPD located outdoors or indoors in non-environmentally controlled rooms: NEMA 4X, Type 316 stainless steel. Enclosures shall have a smooth, non-brushed finish.

C. Manufacturer: Surge Suppression Inc. Advantage™ Series, Eaton Innovative Technology Protector Model PTX, or approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install panelboards at the locations shown on the PLANS.

B. Top of all panelboards shall be at no higher than 6'-6" above the finished floor elevation.

C. Panelboard Identification:

1. Alternating Current "AC" Panelboards: Give panelboard characteristics on 3-ply phenolic "Black-White-Black" laminated nameplate with ½" lettering. Nameplate shall include Panelboard name, voltage ratings, phase, wire, ampere rating, AIC and withstand current rating, and size and type of the main circuit breaker OR Main Lug Assembly (as applicable).

2. Branch Circuit Breaker Cover of Alternating Current "AC" Power Distribution Type Panelboards: Give circuit breaker characteristics on 3-ply phenolic "Black-White-Black" laminated nameplate with 3/16" lettering. Nameplate shall include identification name and tag of the load served by the circuit breaker, ampere rating (size) of the circuit breaker, and circuit breaker make and complete catalog/model order number.

3. Direct Current "DC" Panelboards: Give panelboard characteristics on 3-ply phenolic "Blue-White-Blue" laminated nameplate with ½" lettering. Nameplate shall include Panelboard name, voltage ratings, phase, wire, ampere rating, AIC and withstand current rating, and size and type of the main circuit breaker OR Main Lug Assembly (as applicable).

D. Branch Circuit Breaker Cover of Direct Current "DC" Panelboards: Give circuit breaker characteristics on 3-ply phenolic "Blue-White-Blue" laminated nameplate with 3/16" lettering. Nameplate shall include identification name and tag of the load served by the circuit breaker, ampere rating (size) of the circuit breaker, and circuit breaker make and complete catalog/model order number. Balance phases as closely as possible and test panel in accordance with Section 16800 and type in directory at the close of the job. Use erasable pencil to indicate "Spares" and "Spaces".

E. Use "Unistrut" or approved equal Stainless Steel channel supports and fittings for installation, i.e., do not mount/support any panelboard directly to building walls. Gauge of the Stainless Steel channel shall be in compliance to the requirements of Section 16150 "Raceways, Fittings and Supports" for Support of Electrical Equipments and Raceways. However all fastening hardware, fittings, supports, base posts, clamps, channel nuts, framing

system, etc. shall be fabricated with 316 stainless steel,. Use split ring lock washers with all fastening hardware. Also refer to details shown on the PLANS.

F. Refer to specification Section 16200 "Wiring (600 Volts and Below)" for special and specific field wiring termination requirements.

G. The DCISS shall customize the 250/125 Volts "DC" Power Distribution Panelboards as required to meet the requirements of the PLANS and Specifications.

3.02 MEASUREMENT AND PAYMENT

A. No separate measurement or payment for work performed under this Section. All costs are included in the Base Bid.

END OF SECTION

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SECTION 16520

AUTOMATIC TRANSFER SWITCH AND BYPASS ISOLATION SWITCHES

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required to provide, and make ready for operation, the 480-volt 3-phase Automatic Transfer Switch (ATS) complete with Bypass Isolation Switches, as specified herein and as shown on the PLANS.

B. Furnish all labor, materials, equipment and incidentals required to provide, and make ready for operation, the 240-volt single phase Automatic Transfer Switch (ATS) complete with Bypass Isolation Switches, as specified herein and as shown on the PLANS.

C. Install each Automatic Transfer Switch (ATS) in a NEMA-12 gasketed enclosure, where shown on the PLANS. The ATS shall automatically transfer power from one power source to another, in the event of normal/primary power source failure, one primary feeder failure, etc. The ATS (and the bypass-isolation switches) shall insure continuity of the power supply for as long as one of the two primary feeders to the ATS and the bypass-isolation switches is active.

1.02 RELATED REQUIREMENTS

A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.

B. It is the CONTRACTOR's responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR's Work

C. The PLANS designate the size, rating, and other requirements of the ATS.

D. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

1.03 QUALIFICATIONS

A. The ATS shall be designed, constructed, and tested in accordance with the latest applicable requirements of NEMA, ANSI, U.L., and NEC standards including:

ANSI 68.1	NEMA AB-1	UL508	UL 845
ANSI 255.1	NEMA ICS-1	UL 98	UL1008

NFPA70	NEMA ICS-2	UL 498	

B. The "ATS" shall be as manufactured by "Automatic Switch Company-ASCO", 7000 Series, Russelectric Inc., and no equal. The "ATS" shall be furnished and installed, complete with Bypass Isolation Switches, meeting these specifications and all the additional options required hereinafter.

1.04 SUBMITTALS

A. Submit Shop Drawings in accordance with Section 01300 of the Contract Specifications. Submittals shall include dimensions, wiring diagrams, component listings by manufacturer, catalog numbers, nameplate schedules, and overall individual equipment control schematic, Connection detail drawings, physical layout and detail drawings, and cross sectional view drawings. Submittals shall also include test result sheets and/or tables indicating product data and factory test results, field test results.

B. Submit Operations and Maintenance Manuals (O&M) in accordance with Section 01730 of the Contract Specifications. O&M Manuals shall include copies of the approved shop drawings. Also, as minimum the Operations and Maintenance Manuals shall include:

1. Copies of certified and approved shop drawings.

2. Detailed information on each component used, including:

   a. Installation and operation manual.

   b. Renewal parts bulletin.

   c. Approved shop drawings.

   d. As built drawings.

   e. Test data.

   f. Detailed transfer switch setting parameters, DIP-switch settings, ranges, options, operating setting and calibrating instructions, etc.

1.05 STORAGE AND HANDLING

A. Protection

1. The Contractor, and hence the ATS supplier, shall be responsible for safety of the ATS during storage, transporting and handling.

2. At all times the ATS shall be housed inside a moisture free weatherproof housing.

3. At all times the ATS shall be housed inside a moisture free, non-porous, extra heavy duty plastic weatherproof housing.

4. Interior and exterior of the ATS shall be kept clean at all times.

5. Size, furnish and install temporary space heaters within the ATS and energize during storage and installation for humidity control.

B. Additional project job site storage requirements: Upon delivery to the project site and prior to final installation, protect and store in accordance with the following:

1. Environmentally protected and stored in climate controlled (temperature, humidity, and non-corrosive class) environment at the job site. Size, furnish and install temporary gaseous air scrubbers, air conditioners, and additional environmental control equipment complete with branch circuiting conduit/wire as required to maintain in a controlled environment at the following conditions:

a. Ambient Dry Bulb Temperature:

1) Minimum: 68 degrees Fahrenheit.

2) Maximum: 85 degrees Fahrenheit.

b. Ambient Relative Humidity: Maximum: 50%.

c. Ambient Corrosion Level: International Society of Automation Class: G1

2. Every effort shall be made to provide all necessary electrical power connections ready for immediate connection to equipment upon arrival of equipment on jobsite.

3. Upon arrival of equipment onto job site, a maximum of one day shall be allowed for equipment to be left without to allow proper transition of power of equipment, especially any 120 VAC powered equipment, to ensure all air conditioning, heating, and gaseous air scrubbing equipment are fully operational with a maximum of a 10 minute down time during this transition of power.

4. Furnish and install replacement air scrubber media, air filters, etc., as required for proper operation of the environmental control equipment.

PART 2 - PRODUCT

2.01 AUTOMATIC TRANSFER AND BYPASS-ISOLATION SWITCHES REQUIREMENTS AND UNIT DESCRIPTION

A. General:

1. Automatic transfer and bypass-isolation switches shall be provided to manually permit convenient electrical bypass and isolation of the automatic transfer switch for testing and maintenance purposes without interrupting the load.

2. Bypass of the load to either the Normal or Emergency (alternate) power source with complete isolation of the automatic transfer switch shall be possible regardless of the status of the automatic transfer switch.

3. The bypass-isolation switch shall permit proper operation by one maintenance person through the movement of a maximum of two (2) handles at a common dead-front panel.

4. The entire system shall consist of two (2) elements:

   a. The automatic transfer switch, and

   b. The bypass-isolation switches.

5. Both elements of the ATS (automatic transfer switch and the bypass-isolation switches) shall be completely factory interconnected, pre-wired and tested.

B. Automatic transfer switch mechanism shall be of the electrically operated, double throw mechanically held type, actuated by a single solenoid operator momentarily energized to assure quiet operation.

C. Automatic transfer switch shall be inherently interlocked, mechanically in either normal or emergency position with no "OFF" position possible. Gravity or spring operated switches will not be acceptable.

D. The operating speed of the bypass switch contacts shall be the same as the automatic transfer switch and independent of the speed of operation of the bypass handle.

E. All main contacts shall be provided with silver alloy material for high conductivity under all conditions of service. The transfer switch shall be suitable for all classes of loads, including inductive loads, resistive loads, control loads, and electrical discharge and tungsten-filament loads.

F. Power failure relays shall be provided to sense when the voltage of any phase drops below 70% of normal and cause transfer of the load to the emergency source and to sense when all normal source phase voltages are 90% of rated voltage and re-transfer to normal source at the point.

G. Failure of any control relay coil shall initiate transfer to the backup source.

H. The operating transfer time of the contacts in either direction (emergency or normal power mode) shall not exceed one-sixth (1/6) of a second.

I. Inspection of all contacts (movable and stationary) shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. A manual operating handle shall be provided for maintenance purposes. The handle shall permit the operator to stop the contacts at any point throughout the entire travel to properly inspect and service the contacts when required.

J. The ATS shall conform to the requirement of NEMA standard ICS 2-447 and U.L. 1008 and shall be U.L. listed for:

1. Use in emergency and standby systems in accordance with articles 517, 700, 701 and 702 of the National Electrical Code (NEC).

2. Rated in amperes for total system transfer including inductive loads, resistive loads, control loads, and electrical discharge and tungsten-filament loads.

K. The ATS shall have a U.L. listed minimum RMS symmetrical short circuit current rating equal to or greater than the minimum RMS symmetrical short circuit current rating shown on the PLANS. However, under no circumstances shall the U.L. listed minimum RMS symmetrical short circuit current rating be less than 42,000 amperes at 480 volts AC for 480 volts AC rated ATS assemblies or less than 10,000 amperes at 240 volts AC for 240-volt AC rated ATS assemblies. The ATS contacts rating and number of poles shall be as shown on the drawings (electrical one line diagrams). Additionally, the electrical ratings of the bypass-isolation switch shall equal or exceed those of the associated automatic transfer switch.

L. Transfer from normal power to backup (alternate) power source shall not take place until backup power is available at the proper operating voltage and frequency levels (i.e., 90% of rated voltage and 60 hertz).

M. The automatic transfer switch and bypass-isolation switch shall be the product of one manufacturer and be completely factory interconnected and tested so that only the service and load connections to the bypass-isolation switch are required for the field. The entire unit shall be furnished complete with the automatic transfer control system.

N. All interconnections between the automatic transfer switch, bypass switches and isolation switches shall be silver plated copper bus bar.

O. A visual position indicator shall be provided to indicate availability of the NORMAL and BACKUP (alternate) sources of power. Additionally, a prominent and detailed instruction plate shall be furnished for convenient operation.

P. The automatic transfer switch ATS, automatic control transfer system, sensors, timers, bypass-isolation switch, etc. shall all be mounted, as one unit, in a single NEMA-12 gasketed free-standing enclosure, as specified hereinafter. The ATS shall be mounted where shown on the PLANS.

2.02 AUTOMATIC TRANSFER SWITCH ATS CONTROL REQUIREMENTS

A. Voltage and frequency sensing:

1. Normal power source closed differential voltage sensors on all phases of the normal power source. Pickup voltage to be field adjustable from 85% to 100% of nominal, and the dropout to be adjustable from 75% to 98% of the pickup value.

B. Backup (alternate) power source: pickup voltage to be field adjustable from 85% to 100% of nominal. Pickup frequency to be field adjustable from 90% to 100% of nominal (nominal = 60 hertz). Transfer time delays:

1. Time delay to override momentary normal power source outages to delay transfer switch. Field adjustable from 0.5 to 6 seconds (0.5 to 6 seconds).

2. Time delay to re-transfer to normal power source: Time delay to be provided for re-transfer from backup to normal power source (if restored and within present acceptable operating parameters). This time delay is to be automatically bypassed in the event the backup source fails and normal power source is available. Re-transfer time delay to be field adjustable from 0 to 30 minutes.

3. Transfer to backup power source time delay: Field adjustable form 1 to 300 seconds (0 to 5 minutes) for controlled load transfer to backup power source if the backup power source is at or better than the minimum acceptable preset voltage and frequency levels. Time delay relay to begin timing-out only after the voltage and frequency levels of the backup power source are at or better that the minimum settings.

C. Manual transfer switch controls:

1. Combination Display and Keypad: Provide manufacturer's standard four line, 20 character liquid crystal display (LCD) combination display and pushbutton keypad user interface module. The combination display and keypad module shall be an integral part of the ATS for viewing all available data and field adjustment of desired operational parameters. Mount the Combination Display and Keypad to the face of the ATS.

2. Pushbuttons and Selector Switches: Heavy duty NEMA rated pushbuttons and selector switches with the number of contact blocks required by the manufacturers schematic diagrams. Selector switches and pushbutton contacts shall be per manufacturer's standard.

3. Normal power source simulation test switch: A test push-button switch to momentarily simulate normal power source failure. Switch to be installed and connected on the door of the ATS cabinet. Reset switches shall be as required by paragraph 2.02 C. 1, above.

4. Non-delayed (immediate) manual re-transfer switch: A reset pushbutton switch to manually bypass the preset time delay on re-transfer to the normal power source. Reset switches shall be as required by paragraph 2.02 C. 1, above.

D. Indicating lights:

1. General:

a. Indicating lights shall be Heavy duty NEMA rated indicating lights per manufacturer's standard.

2. System connected to normal power source "gree light": Signal light (gree) to indicate automatic transfer switch is connected to normal power source. Indicator light shall be mounted on the door of the ATS cabinet. Type of pilot light to be as required by paragraph 2.02 D.1, above.

3. System connected to backup power source "red light": Signal light (red) to indicate automatic transfer switch is connected to backup power source. Indicator light is to be mounted on the door of the ATS cabinet. Type of pilot light to beas required by paragraph 2.02 D.1, above.

E. Additional spare auxiliary contacts:

1. Furnish unit with the following additional spare contacts over the number of contacts required to meet the requirements of this specification, and the number of contacts required by the automatic transfer switch control schematics:

    a. Two (2) auxiliary normally open dry contacts. Contacts are to change state to closed-position when the automatic transfer switch is connected to backup (alternate) power source. Contacts shall be rated 10 amps at 120VAC. Each contact is to clearly be marked as spare.

    b. Two (2) auxiliary normally open dry contacts. Contacts are to change state to closed-position when the automatic transfer switch is connected to normal power source. Contacts shall be rated 10 amps at 120VAC. Each contact is to clearly be marked as spare.

2.03 ADDITIONAL OPERATING AND CONTROL REQUIREMENTS FOR THE AUTOMATIC TRANSFER AND BYPASS-ISOLATION SWITCHES ASSEMBLY/UNIT

A. The automatic transfer and bypass-isolation switch shall provide manual bypass of the load and isolation of all service and load terminals of the automatic transfer switch to permit periodic testing, reactive maintenance and proactive maintenance of the automatic transfer switch without interrupting power to the load.

B. The bypass-isolation switch shall be capable of bypassing the load to either source. Load bypass to the automatic transfer switch's connected source shall be affected without load interruption. Provisions shall be made to assure continuity of auxiliary circuits necessary for the proper operation of the system.

C. The isolation switch handle shall provide three (3) positions as follows:

    1. Closed

    2. Test

    3. Open

D. The TEST position of the isolation switch shall permit electrical testing of the automatic transfer switch without disturbing the load.

E. The OPEN position of the isolation switch shall completely isolate the automatic transfer switch from both sources of power (normal and backup/alternate) and the load without actual removal of the power source conductors or the load power conductors, and allow the removal of the automatic transfer switch for inspection, adjustment and maintenance. The automatic transfer switch shall be arranged for draw-out operation to facilitate its removal.

F. While the isolation switch is in TEST or OPEN positions, the bypass switch shall function as a manual transfer switch to allow load transfer to either source of power (normal or backup/alternate) regardless of the position or the condition of the automatic transfer switch, including the condition when the automatic transfer switch is removed, and without connecting the load terminals of the automatic transfer switch.

2.04 ATS ENCLOSURE

A. The Automatic Transfer Switch ATS assembly (controls, contactors, sensors, relays, bypass and isolation switches, etc.) shall all be mounted in a single free-standing NEMA-12 gasketed enclosure. All indicating and control pilot devices, etc. shall be mounted on the face of the enclosure door. Door shall have a continuous piano hinge with key-lockable stainless steel handle (3-point latching mechanism).

PART 3 - EXECUTION

3.01 FACTORY INSPECTION AND TESTS

A. The ATS (complete with the bypass-isolation switches) shall be completely assembled, wired, and adjusted at the factory and shall be given the manufacturer's routine shop test and any other additional operational test to insure the workability and reliable operation of the equipment.

B. Factory test equipment and test methods shall conform with the latest applicable requirements of ANSI, IEEE, U.L., and NEMA standards, and shall be subject to the Engineer's approval.

3.02 FIELD INSTALLATION (BY CONTRACTOR)

A. All field wiring shall be tagged and coded with an identification number. All wiring material and tagging and wire marking material and methodology shall be as required by Section 16200 of the Specifications Wiring (600 Volts and Below). Mount the ATS on housekeeping concrete pad, refer to housekeeping pad details shown on the PLANS. Utilize Stainless Steel equipment support channels as required, gauge of the Stainless Steel support channels shall be in compliance to the requirements of Section 16150 "Raceways, Fittings and Supports". However all fastening hardware, fittings, supports, base posts, clamps, channel nuts, framing system, etc. shall be fabricated with 316 stainless steel. Also refer to details shown on the PLANS.

3.03 FIELD TEST AND CHECKS

A. The following minimum test and checks shall be made before energizing the Automatic Transfer ATS. These tests shall be performed by a Factory Trained Field Technician (non sales type):

1. Thoroughly inspect ATS for items such as loose connections and presence of foreign material and broken parts, and remedy prior to energizing.

2. Check all mechanical interlocks for proper operation.

3. Calibrate, set and test control timers, relays according to settings provided and required by this Specifications Section and as recommended by the manufacturer.

4. Submit documentation of all tests outlined above. Include all test documentation data in operation and maintenance manuals.

3.04 REFER TO CALIBRATION, SETTING AND TESTING REQUIREMENTS OF SECTION 16800. EQUIPMENT PROTECTION AND RESTORATION (BY CONTRACTOR)

A. Clean and vacuum clean all interior of the equipment.

B. Touch-up and restore damaged surfaces to factory finish.

C. After all connections have been made, the Contractor shall spray all terminals, terminal blocks with a moisture repelling chemical such as provided by CRC or Dow Chemical Corporation or approved equal.

D. Notify the Engineer 24 hours prior to intent to spray the ATS Assembly. If no such notification is made it will be presumed that moisture proofing has not been accomplished.

3.05 EQUIPMENT IDENTIFICATION NAMEPLATES

A. General:

Provide nameplates/legend plates for each control station, and each pilot device and each component/device/equipment installed on the face and inside the enclosure of the ATS.

B. Identification Nameplates, unless otherwise specified, shall be constructed of 3-ply "Black-White-Black" laminated phenolic material having engraved Roman-Gothic letters approximately ¼-inch high extending through the black face into the white layer. Nameplates located on the face of the cabinet shall be secured with two Stainless Steel screws.

3.06 TRAINING

A. Provide training sessions for owner's representatives for Two (2) normal workdays and Eight (8) working hours each day, at the job-site location. If training is conducted in less than the time required by these specifications, the remaining time shall be utilized at the discretion of the Owner.

B. The training session shall be conducted by the ATS manufacturer's non-sales-type technical representative.

C. At minimum, the training session shall include:

1. Operation and maintenance procedure for the equipment and all components installed within the ATS.

2. Factory contact persons phone numbers, persons names, ordering procedures and procedures to follow to obtain meaningful results from the factory.

3.07 MEASUREMENT AND PAYMENT

A. No separate measurement or payment for work performed under this Section. All costs are included in the Base Bid..

END OF SECTION

SECTION 16550

GROUNDING

PART 1 - GENERAL

1.01 SCOPE

A. Provide grounding in accordance with the Plans, these Specifications and the National Electrical Code "N.E.C.". Included within this section are furnishing and installing all the wire, rods, connections, ground plates, and other devices associated with the grounding system.

1.02 SUBMITTALS

A. Submit shop drawings on all grounding system product and in accordance with Section 01300 of the Contract Specifications.

B. Submit Operations and Maintenance Manuals (O&M) in accordance with Section 01730 of the Contract Specifications. O&M Manuals shall include copies of the approved shop drawings, and on-site/field test data.

PART 2 - PRODUCTS

2.01 GENERAL

A. Grounding Electrodes: Unless otherwise noted on the PLANS, grounding electrodes shall be assumed to be ground plates. Where specifically noted on the PLANS, ground rods may be used in lieu of ground plates.

1. Ground plates shall be high conductivity copper sheet plates as manufactured by Erico, or approved equal. Ground plates shall be furnished complete with manufacturer's factory attached welded pigtail conductor. Pigtail conductor size shall be equivalent to the size of the grounding conductor that terminates to the ground plate as shown on the PLANS.

   a. Ground plates installed in all areas except at ground test wells shall be 24 inch long by 24 inch wide. Minimum thickness shall be 1/4 inch thick. Contractor shall use ground enhanced material (GEM) for backfilling around ALL ground plates.

   b. Ground plates installed at ground test wells shall be 24 inch long by 24 inch wide by 1/4 inch thick. Ground plate shall be factory assembled with female threaded coupler attached to the ground plate via a welded bond. The coupler shall facilitate attachment of a 3/4-inch diameter sectional ground rod to the ground test well ground plate assembly.

2. Ground rods shall be 3/4-inch diameter by 15’-0” long, copper clad steel by Thermoweld, Erico, or approved equal.

    a. Exception: Where ground rod is installed as part of an assembly with ground plate at ground test wells, ground rod shall be 3/4-inch diameter by 4’-0” long, copper clad steel sectional type ground rods by Thermoweld, Erico, or approved equal. Refer to the PLANS.

B. Connections between ground plates/rods and grounding electrode conductors shall be made below grade using Cadweld, Burndy Thermoweld, or equal thermite reaction welding system. Exception: Connections between ground plates/rods and grounding electrode conductors made inside an accessible underground Grounding System Test Well, only where noted/detailed/shown on the PLANS, shall be permitted to be made with tin-plated Bolted Ground Lug connectors as manufactured by BURNDY Type GK, or approved equal.

C. Grounding electrode conductors/wire shall be green insulated XHHW-2 stranded copper. Use bare copper for grounding grids only (as shown on the PLANS) only.

D. Equipment and/or static voltage and/or any other ground buses/bars (for any other type of use) called for on the PLANS and Specifications shall be tin-plated copper.

PART 3 - EXECUTION

3.01 GENERAL

A. Ground all electrical equipment, including lights and receptacles, etc., with a separate equipment ground wire installed in the conduit with the power conductors.

B. Install grounding system electrically and mechanically continuous throughout. Do not bond to the system neutral except at the building service transformer.

C. Ground lighting transformer neutrals to their housing and bond the housing to the equipment grounding conductor.

D. Connect equipment grounding conductors to ground bars or busses provided at panelboards, motor control centers, disconnect switches, switchgears, etc., from which the equipment is served.

E. Where the equipment has no facility to attach an equipment ground wire, use a compression lug by Burndy, Thomas & Betts, 3M, or approved equal. Clean the metal surface under the lug to bright metal so that good contact can be made. Repaint metal surfaces after the lug and connecting ground wires are installed.

F. Make ground connections to equipment by using ground lugs or ground bars, where they are provided. Do not make connections to equipment anchor bolts.

G. Use 316 stainless steel split ring or star type lock washers on all bolted grounding terminations to non-threaded ground bars, busses, spades, or other terminals. Additionally, refer to details shown on the PLANS.

H. Use a thermite reaction welding system process as previously specified, by Burndy Thermoweld, Cadweld, or approved equal, to make connections to ground plates/rods; and, at any joint or connection which will be inaccessible after the construction. Exception: Connect to Grounding System Test Wells as previously specified and as also shown on the PLANS. Do not cover until each connection has been inspected by the Owner.

I. Furnish bonding jumpers as shown or as otherwise required by the National Electrical Code "N.E.C." Use stranded copper wire.

J. Inside buildings and at above ground level and through concrete floor slabs, route the ground wire(s) in PVC Schedule-40 conduit system DO NOT RUN GROUND WIRING EXPOSED AND/OR UNPROTECTED AND/OR NOT CONTAINED WITHIN A CONDUIT RACEWAY SYSTEM. Fill annular space between ground wire and conduit with Crouse Hinds, Nelson or Raychem watertight and flame-retardant sealant.

K. Through concrete walls of underground vaults, manholes and handholes, route the ground wire(s) in PVC Schedule-40 conduit system. Also refer to details shown on the PLANS.

   1. Where installed in existing structures, fill annular space between PVC conduit and concrete structure with 50-year, non-shrink, water-tight grout.

   2. Install conduit sealing fitting on PVC conduit exterior to vault, manhole or hand hole concrete wall.

      a. Sealing fitting shall be constructed of 99% copper-free aluminum as manufactured by Crouse Hinds, Type EYS, or approved equal.

L. Fill conduit seals with sealing compound as manufactured by "Crouse-Hinds" type Chico-AP, or approved equal. Connect ground wires entering outlet boxes in such a manner that removal of the receptacle will not interrupt the continuity of the grounding circuit. A grounding screw attached to the box, and used for no other purpose, may be used to accomplish this.

M. ALL GROUND WIRING CONNECTIONS/TERMINATIONS MUST BE PROTECTED AGAINST CORROSION by applying generous quantities of 3M 1601 Clear-Color Fast Drying Sealer and Insulator, or approved equal by Dow Chemical, corrosion resistant and moisture repelling Electrical Coating/spray and moisture repelling Electrical Coating to all grounding termination points inside outlet boxes, junction boxes, pull boxes, lighting fixtures, receptacle boxes, light switches, manual motor starter stations, disconnect switches, enclosed circuit breakers, combination motor starters, control panels, 480 volt motor control centers, transformers, panelboards, wireways, medium voltage switchgears, automatic transfer switches, field instruments/devices, field control stations, solenoid valves, motors, all mechanical equipment, field control panels, etc. Also, refer to Specification Section 16200 "Wiring (600 Volts and Below)".

N. Test grounding in accordance with Section 16800. Maximum resistance to ground shall not exceed 2-ohms. At no additional cost to the owner, install additional ground plates/rods over the number required by the drawings, as necessary to accomplish the 2-ohms or less resistance.

O. Install a bonding jumper from the grounding lug of each conduit grounding bushing to the ground bar or bus of each enclosure and/or equipment housing (such as pull boxes, junction boxes, panelboards, switchgears, disconnect switches, transformers, instrument and control panels, DC Power distribution assemblies, Battery Chargers, Battery Banks, DC Power Inversion system assemblies, etc.), as applicable. DO NOT connect equipment ground wire (routed through conduit system) to conduit grounding bushings. Also refer to details shown on the PLANS. Bonding jumper wire for conduit system grounding bushings shall be STRANDED bare copper wire with minimum of 19-strands. Wire size shall be in accordance with National Electrical Code "N.E.C." requirements, however, the minimum wire size permitted shall be #10 AWG.

P. Where splicing to existing phase conductors is required inside of existing underground electrical manholes and/or handholes, and/or where routing of new (proposed) phase conductors is required inside/through existing underground electrical manholes and/or handholes, install 400 amperes rated, tin-plated copper Ground Bus/Bar inside of the existing electrical manhole and/or handhole. Each Ground Bus/Bar shall be as manufactured by General Electric Company "G.E.", Cutler-Hammer, or Square-D Company. Adhere to the following minimum assembly and system installation requirements:

1. Mount the Ground Bus/Bar with 600 volts AC stand-off isolators/insulators, as manufactured by General Electric Company "G.E.", Cutler-Hammer, or Square-D Company. The 600 volt insulators/isolators shall be spaced at a maximum distance of 12-inches apart.

2. Each Ground Bus/Bar shall have a minimum length of 2-feet.

3. Each Ground Bus/Bar shall be furnished with a minimum of twelve (12) terminals (ground lugs). Each terminal (Grounding lug) shall be capable of terminating various sizes of wire ranging from #10 AWG to #4 AWG. Additionally, connect each Ground Bus/Bar directly to the grounding network of the associated Process Building Electrical Room (as shown on the PLANS), the Underground Electrical Distribution System, and the grounding system around the Electrical Manholes and Handholes. Utilize #250 AWG 600 volts GREEN insulated type XHHW-2 ground wires for connection to the Ground Bus/Bar.

4. Extend a dedicated equipment ground wire from each Ground Bus/Bar to each conduit system grounding bushings, cable-clamps, support channels, support systems, etc. housed inside the associated electrical manhole and electrical handhole. Do not connect/terminate more than one (1) equipment ground wire to a single terminal point on the Ground Bus/Bar. Additionally, DO NOT daisy-chain equipment ground wire from one support system, support channel system, cable clamp, etc. to another. Moreover, DO NOT connect/bond equipment ground wire of one system to another with direct ground wire connection to the Ground Bus/Bar. Each support channel, cable-clamp, conduit grounding bushing, etc. shall have its own individual equipment ground wire routed (home-run) directly to its associated Ground Bus/Bar. Wire size shall be in accordance with National Electrical Code "N.E.C." requirements, however, the minimum wire size of each of the dedicated equipment ground wires shall be #6 AWG (600 volts, green insulated wire). Also, refer to the PLANS.

Q. Install 400 amperes rated, tin-plated copper Ground Bus/Bar inside of each electrical manhole (new/proposed and existing manholes) and inside of each electrical handhole

(new/proposed and existing handholes). Each Ground Bus/Bar shall be as manufactured by General Electric Company "G.E.", Cutler-Hammer, or Square-D Company. Adhere to the following minimum assembly and system installation requirements:

1. Mount the Ground Bus/Bar with 600 volts AC stand-off isolators/insulators, as manufactured by General Electric Company "G.E.", Cutler-Hammer, or Square-D Company. The 600 volt insulators/isolators shall be spaced at a maximum distance of 12-inches apart.

2. Each Ground Bus/Bar shall have a minimum length of 3-feet.

3. Each Ground Bus/Bar shall be furnished with a minimum of twelve (12) terminals (ground lugs). Each terminal (Grounding lug) shall be of tin-plated copper, capable of terminating various sizes of wire ranging from #10 AWG to #4 AWG. Additionally, connect each Ground Bus/Bar directly to the Grounding Network of all the various systems as well as the Grounding System around the Electrical Manholes and Handholes, as also shown on the PLANS. Utilize #250 AWG 600 volts GREEN insulated type XHHW-2 ground wires for connection to the Ground Bus/Bar.

4. Extend a dedicated equipment ground wire from each Ground Bus/Bar to each individual conduit system grounding bushings, each individual medium and low voltage cable-clamps, each medium and low voltage cable support channels, each strip of support channels, etc. housed inside the associated electrical manhole, and electrical handhole. DO NOT connect/terminate more than one (1) equipment ground wire to a single terminal point on the Ground Bus/Bar. Additionally, DO NOT daisy-chain equipment ground wire from one support system, support channel system, cable clamp, etc. to another. Moreover, DO NOT connect/bond equipment ground wire of one system to another with direct ground wire connection to the Ground Bus/Bar. Each individual support channel, cable-clamp, conduit grounding bushing, each cable support channel, etc. shall have its own individual equipment ground wire routed (home-run) directly to its associated Ground Bus/Bar. Daisy Chaining of ground wire WILL NOT BE PERMITTED. Also, refer to the PLANS. Wire size shall be in accordance with National Electrical Code "N.E.C." requirements, however, the minimum wire size of each of the dedicated equipment ground wires shall be #6 AWG (600 volts, green insulated wire). Also, refer to the PLANS.

R. Install 600 amperes rated, tin-plated copper Ground Bus/Bar in the designated <u>TEST AREA</u> (testing area of circuit breakers, switchgear components, etc.) which is located inside the Substation No. 1 Building, refer to PLANS. Each Ground Bus/Bar shall be as manufactured by General Electric Company "G.E.", Cutler-Hammer, or Square-D Company. Adhere to the following minimum assembly and system installation requirements:

1. Mount the Ground Bus/Bar with 600 volts AC stand-off isolators/insulators, as manufactured by General Electric Company "G.E.", Cutler-Hammer, or Square-D Company. The 600 volt insulators/isolators shall be spaced at a maximum distance of 12-inches apart.

2. Each Ground Bus/Bar shall be of high conductivity tin-plated copper with a continuous rating of not less than 1200 amperes. The Ground Bus/Bar shall extend the entire LENGTH and WIDTH shown on the PLANS. The routing of the Ground Bus/Bar shall

be continuous and shall have Electrical and Mechanical Continuity. Refer to details shown on the PLANS.

3. The Ground Bus/Bar shall be furnished with a minimum of Twenty (20) terminals (ground lugs). Each terminal (Grounding lug) shall be of tin-plated copper, capable of terminating various sizes of wire ranging from #10 AWG to #1 AWG Additionally, connect each Ground Bus/Bar directly to the main grounding network of the Substation Facility via #250 AWG 600 volts GREEN insulated type XHHW-2 ground wires (refer to the PLANS).

S. Install underground and/or above ground Grounding System Testing Well as shown and required by the PLANS. However, under no circumstances shall less than one (1) underground and/or above ground Grounding System Testing Well be installed per building and process structure. Underground Grounding System Testing Wells shall be housed in an underground precast concrete pull box as detailed and called for on the PLANS. Above ground Grounding System Testing Wells shall be housed in an above ground 316-Stainless Steel box as detailed and called for on the PLANS. Tag each grounding electrode conductor entering the grounding system test well with the source and destination identification nameplate. Identification nameplate shall be 3-ply phenolic "White-Green-White" nameplate. Attach nameplate to each grounding electrode conductor inside the well with plastic wire ties. The size of the lettering shall be 3/8" high Roman-Gothic Type lettering. The inscription of the destination tag on the Identification Nameplate shall be placed within parenthesis. Both inscription of source and destination tags of each grounding electrode conductor shall be placed on the same Identification Nameplate of the respective grounding electrode conductor. Each ground rod/plate within an underground test well shall also be tagged by a unique Alphanumeric name that shall be unique within the entire plant. The tag shall have a prefix that represents the process area code within the plant, followed by a 2-digit number that represents the total count of ground plates/rods within the process area, followed by an Alphabetical number that represents the unit number of the test well within the process area.. The ground rod/plate Identification Nameplate shall be 3-ply phenolic "White-Green-White" nameplate. Attach ground rod/plate Identification nameplate to each ground rod/plate inside the test well with plastic wire ties. The size of the lettering shall be 3/8" high Roman-Gothic Type lettering. Ground rod/plate installed within the grounding system test well shall have its end be exposed a distance of 12-inches WITHIN only the boundaries of the TEST WELL and only INSIDE the TEST WELL (i.e., when the cover of the test well is shut, the ground rod/plate shall be concealed and be buried inside the test well). All connections between ground plates/rods and grounding electrode conductors inside the test wells shall be made with 400 ampere tin-plated Bolted Ground Lug connections as manufactured by BURNDY type QPX, or approved equal.

T. Where Grounding System bare copper underground conductors pass through a transition from soil to concrete/mud slab concrete/flowable fill concrete/etc., the conductors shall be wrapped with 20 mil polyvinyl chloride based Pipe Tape using a 50 percent overlap. Pipe tape coverage shall be installed at the point of the transition and an additional 12 inches of distance beyond either side of the point of transition/contacted region. Pipe Tape shall be 3M Company No.51, or approved equal.

3.02 MEASUREMENT AND PAYMENT

A. No separate measurement or payment for work performed under this Section. All costs are included in the Base Bid.

END OF SECTION

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SECTION 16600

DISCONNECT SWITCHES AND ENCLOSED CIRCUIT BREAKERS

PART 1 - GENERAL

1.01 SCOPE

A. Furnish and install enclosed circuit breakers as indicated on the PLANS and specified herein. All enclosed circuit breakers are to be molded case type, NEMA rated, and U.L. Listed. So called "International" and IEC rated circuit breakers will not be accepted even if they were to show equivalent NEMA ratings.

1.02 RELATED REQUIREMENTS

A. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

1.03 SUBMITTALS

A. Submit Shop Drawings in accordance with Section 01300 of the Contract Specifications. Include disconnect switch and enclosed circuit breaker dimensions, ratings, wiring connection diagram and fabrication drawings. Submit protective device coordination curves and current limiting circuit breaker/fuse peak current let through curves, where applicable.

B. Submit Operations and Maintenance Manuals (O&M) in accordance with Section 01730 of the Contract Specifications. O&M Manuals shall include copies of the approved shop drawings, and on-site/field test data.

1.04 ACCEPTABLE MANUFACTURERS

A. Furnish units manufactured by Cutler-Hammer, General Electric Company “G.E.”, or Square-D Company.

PART 2 - PRODUCTS

2.01 DISCONNECT SWITCHES

A. Unless otherwise noted on PLANS, all electrical equipment denoted on PLANS as “Disconnect Switch” or “Disconnect” shall be the enclosed circuit breaker as described in this section of the specifications.

2.02 ENCLOSED CIRCUIT BREAKERS

A. Construction.

1. Circuit breakers to have quick-make and quick-break, trip-free type operating mechanism with inverse time thermal trip and instantaneous time magnetic trip. Provide overload tripping elements in each pole. A tripped condition to be indicated by the breaker assuming a neutral position between “ON” and “OFF”.

2. Circuit breaker shall have handles with provision for padlocking in the ”OFF” position, with at least four padlocks. The locking provisions shall be such that the padlock directly interferes with the operating handle and is fully visible. Multi-pole breakers to be common trip with a single trip handle; handle ties are NOT TO BE USED. Circuit breakers shall have a dual enclosure interlock to prevent unauthorized opening of the enclosure door when the circuit breaker is in the "ON" position, or closing of the circuit breaker mechanism with the door open. All current-carrying parts to be plated through electrolytic processes.

3. Furnish lugs to terminate the incoming/outgoing field wiring as shown on the PLANS. Refer to the PLANS. Each switch to have a grounding lug for equipment ground wire connection. Lugs to be front removable and U.L. listed for copper cables. Circuit breaker shall consist of two (2) form C auxiliary dry contacts. Each such contact shall be integral to the breaker and shall be mechanically interlocked with the breaker position. With the breaker in the open or tripped position, one contact in the form C assembly shall be open and the other closed. Each contact shall change to the opposite state only when the breaker position changes from open/tripped to closed or from closed to open/tripped. Each contact shall be rated at 120 volts A.C., and capable of continuously driving up to a minimum of 5 Amp inductive load.

B. Enclosures

1. Switch and circuit breaker assemblies installed in ALL AREAS shall be enclosed in NEMA-4X 316-Stainless Steel gasketed cabinets. Enclosures shall have a smooth, non-brushed finish. Exception: Enclosed circuit breaker assemblies installed inside the environmentally and climate controlled electrical rooms of the SUBSTATION NO.1 BUILDING shall be enclosed in NEMA-12 gasketed cabinets, the rigidity and gauge of steel to be as specified in U.L. Standard 50 for cabinets. Enclosed circuit breaker assemblies housed in NEMA-12 enclosures shall have ANSI #61 Gray finish.

C. Circuit Breaker Ratings

1. Circuit breaker shall be three pole, 600 volts AC or 250 volts DC with a maximum continuous current carrying capacity shown on the PLANS. 600 volts AC circuit breakers shall have a U.L. listed minimum RMS symmetrical short circuit current rating equal to or greater than the minimum RMS symmetrical short circuit current rating of the line-side (source) bus at 480 volts A.C., unless otherwise indicated on the one-line diagram drawings (refer to the PLANS). Breaker shall be U.L. listed and shall comply with NEMA Standard No. AB1-1975 and Federal Specification W-C-3758/GEN 21a. Circuit breaker shall be fully rated and not require rating for ambient temperatures of 40 degrees C. or less.

2. Construction: Circuit breaker shall be molded case type with overcenter, trip-free, toggle-type operating mechanism with quick-make, quick-break action and positive handle indication, and common trip. Breaker operating handle shall assume a center position when tripped. The circuit breakers shall operate continuously, without tripping, when the continuous operating/running current is equal to 80% of the long time trip setting (or frame rating, as applicable) of the breakers.

3. Terminations: Breakers shall have removable lugs, U.L. listed for copper and aluminum conductors and U.L. listed for installation of mechanical screw type lugs.

4. Furnish current limiting type circuit breakers when specifically required by the one-line drawings shown on the PLANS.

5. Provide electronic trip attachment where specifically shown on the PLANS. Trip unit shall be solid state type with adjustable long time, short time, instantaneous, ground fault and pick up settings as manufactured by "Square D" Micrologic LSIG Series B Trip Unit and Internal Ground Fault Protection, or approved equal.

6. Circuit breakers shall be Square D Company Type FCL, or approved equal by General Electric Company "G.E.", Cutler-Hammer Corporation..

2.03 IDENTIFICATION

A. Each disconnect switch/enclosed circuit breaker shall be provided with identification nameplate engraved with the device name and number exactly at it appears on the one-line diagrams shown on the PLANS. Identification nameplates shall be 3-ply laminated phenolic, "Black-White-Black", nameplates with Roman Gothic 3/8-inch lettering. Nameplates shall be located on the face of the disconnect switch and enclosed circuit breaker enclosures and shall be secured with two 316 Stainless Steel screws.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install disconnect switches and enclosed circuit breakers where the top of each disconnect switch and each enclosed circuit breaker is no higher than 5'-6" above the finished floor indoors and above finished grade outdoors, unless otherwise noted on the PLANS.

B. Surface mount enclosed disconnect switch and enclosed circuit breaker assemblies. Use approved support channels and fittings for installations. i.e., do not mount/support any box/cabinet directly to building walls. Use "Unistrut" or approved equal Stainless Steel channel supports and fittings for securing the installation of the disconnect switch and enclosed circuit breaker assemblies. Gauge of the Stainless Steel channel shall be in compliance to the requirements of Section 16150 "Raceways, Fittings and Supports" for Support of Electrical Equipments and Raceways. All fastening hardware, fittings, supports, base posts, clamps, channel nuts, framing system, etc. shall be fabricated with 316 stainless steel. Use split ring lock washers with all fastening hardware. Also refer to details shown on the PLANS.

C. Free-standing disconnect switches and enclosed circuit breakers shall be mounted on concrete housekeeping pad. Refer to concrete housekeeping pad details shown on the PLANS.

D. Refer to specification Section 16200 “Wiring (600 Volts and Below)” for special and specific field wiring termination requirements.

3.02 MEASUREMENT AND PAYMENT

A. No separate measurement or payment for work performed under this Section. All costs are included in the Base Bid.

END OF SECTION

SECTION 16800

CALIBRATION, TESTING AND SETTING

PART 1 - GENERAL

1.01 SCOPE

A. Provide all equipment and labor required for calibration, setting and testing as described herein or otherwise required. All tests shall be witnessed by the Owner or the Owner's designated representative. Give written notification of the tests at least seven days prior to the desired date to perform the tests. Repair or replace all defective material, equipment or workmanship disclosed as a result of these tests at no cost to Owner.

B. All work, including installation, connection, calibration, testing, and adjustment, shall be accomplished by qualified, experienced personnel working under continuous, competent supervision. The completed installation shall display competent work, reflecting adherence to prevailing industrial standards and methods.

C. Tests: The Contractor shall make all tests required by these specifications, or other authorities having jurisdictions. All such tests shall be performed in the presence of the Construction Manager or his representative. The Contractor shall furnish all necessary testing equipment and pay all costs of tests, including all replacement parts and labor necessary due to damage resulting from damaged equipment or from test and correction of faulty installation.

1.02 TEST PLAN AND TEST RESULTS

A. Performance:

Testing shall be performed in compliance with the successfully reviewed Test Plan. The Test Plan shall be submitted in accordance with the outline given below. Provide the Owner with typewritten results of all tests, including a description of the equipment tested, the date and time of day tested, weather conditions; and test values and results.

B. Test plan:

At minimum, Submit a Test Plan for each of the Sections listed in Division 16 of these specifications. Test Plan shall be submitted at least two (2) weeks prior to the desired date and time of the test. Test Plan shall clearly identify the following, as applicable:

1. Desired date and time to perform the test

2. Name of Entity/individual that shall perform the test

3. Test procedures and recording data sheets

4. Name, description, catalog number, calibration date, and calibration entity's name of each of the test instruments to be used in executing the test

5. Expected duration of the test

6. Request for type, time and duration of any shutdown that may be required during the test.

C. Test Results:

Submit Test Results for each of the Sections listed in Division 16 of these specifications. Test Results shall be submitted no later than at least two (2) weeks after the last date of the respective test. Test Results shall be typewritten and shall include the following, as minimum:

1. All data and information provided in the Test Plan

2. Name of Entities and individuals that attended and witnessed the test

3. Weather Conditions

4. Tabulated test values and results

5. Corrective measures taken and/or to be taken toward defective material, equipment or workmanship disclosed as a result of these tests. Also include Re-Test dates and procedures for defective material, equipment or workmanship disclosed from the previous test.

1.03 GENERAL AND SPECIAL SUBMITTAL REQUIREMENT AND FORMAT:

A. Submittals shall include copies of the test results/reports. Submittals shall be per the quantity and format requirements of Sections 01300 and 01730 of the Contract Specifications.

B. Submit test result sheets and/or tables indicating product data, factory test results, field test results, quantities, physical location and reference, catalog number, reference, wiring diagram drawing number reference, cost, and any other field entered in the test resulting reports sheets and/or any other spreadsheets and/or any other table and/or listings of references/etc. Submittals shall include copies of the quantity and format required by the Contract Documents.

C. Testing Plans shall be submitted in the format required by Section 01300 of the Contract Specifications.

D. All test instrument catalog and product data sheets and/or component data sheets shall be submitted in the format required by Section 01300 and Section 01730 of the Contract Specifications.

1.04 TEST EQUIPMENT

Each test instrument shall have been certified by an established calibration laboratory within the six (6) months prior to its use in testing and calibration procedures. Calibration shall be traceable to the National Bureau of Standards.

PART 2 - PRODUCTS

No products are required by this Section of the Specifications.

PART 3 - EXECUTION

3.01 INSULATION RESISTANCE (MEGGER) TESTS:

A. Use a minimum 1000 volt megohmeter.

B. Take each reading for at least one minute.

C. Include the following tests:

Equipment	Minimum Resistance
115 and 230 volt motors	5.0 Megohms
460 volt motors	7.0 Megohms
4000 volt motors	10.0 Megohms
600 volt transformer windings	100.0 Megohms
600 volt wiring up to 1000 ft.	25.0 Megohms

D. Test all transformer windings as follows:

1. Primary to ground
2. Secondary to ground
3. Primary to secondary

E. Test medium voltage cables, 15kV, in accordance with Specifications Section 16182 “Medium Voltage Cables”.

F. Record and submit all Megger readings to the Owner/Engineer for review and record keeping purposes. Neatly type all readings and organize in a Database table form. Incremental megger readings shall also be recorded and included in the table.

3.02 GROUND RESISTANCE TESTING

A. Ground system testing shall be performed by an independent professional testing company specialized in, and well equipped to perform, ground resistance testing. The ground resistance testing shall at minimum be the fall of potential test in accordance to IEEE Standard #81.

B. Take ground resistance measurements in dry weather, not less than 48 hours after rainfall, with ground under test isolated from other grounds.

C. Ground testing shall assure resistance to ground values listed in the Grounding Specification. Install additional grounding/ground plates/rods if the resistance to ground measures more than the values stipulated in the Grounding Section of these Specifications. This shall be executed at no additional cost to the Owner.

D. All tests must be witnessed by the Owner or the Owner's designated representative.

E. At a minimum, test each of the following separately, with ground system under test isolated from other grounds via ground test wells, ground bars, etc. shown on the PLANS:

1. Each process area/building grounding network, e.g., Substation 1, Chemical Building, Low Service Pump Station, etc.

    a. EXCEPTION: The Substation 1 grounding network shall be tested as a minimum of four (4) equally subdivided grounding network segments. Measure the combined ground resistance of each grounding network segment individually. Then, sequentially measure the combined ground resistance as segments are interconnected with each other; two (2) segments, three (3) segments, and so forth until, finally, the overall Substation 1 grounding network ground resistance measurement is achieved.

        1) Submit to the owner record drawings and test reports in accordance with Subsection 3.02 H of this Specification. Within the submitted drawings and report(s), identify the location of each individual Substation 1 grounding network segment, as tested.

2. Each secondary grounding network/electrode:

    a. at corners of building structure,

    b. at each outdoor pad mounted transformer,

    c. at each manhole,

    d. at each handhole,

    e. at each lighting/security/etc. poles, and

    f. at outdoor pull boxes, where grounding is shown on the PLANS.

F. Finally, after all tests of each individual process area/building, transformer, manhole, handhole, etc., are performed as previously specified, perform a final test after all of the

individual process areas/buildings, transformers, manholes, handholes, etc. grounding networks are interconnected as also shown on the PLANS.

G. Submit to the owner record drawings and test reports indicating the ground grid/grounding electrode location (as applicable), the resistance measured, the soil condition at the time, any re-tests including reasons for re-tests, and time duration of each reading, overall duration of the test, and overall Technical Opinion of the Test Outcome. All tests must be witnessed by the Owner or the Owner's designated representative.

3.03 MOTORS

A. Test the insulation resistance (megger test) of all motors installed under this Contract inclusive of process mechanical drive motors and the Heating and Ventilation System drive motors such as exhaust fans, fan and coil units drive motors, etc. Test all motors in accordance to with Paragraph 3.01 above.

B. Dry out any wet insulation by use of space heaters or other approved methods.

C. Check coupling alignment, shaft end play, lubrication, and other mechanical checks as required. Follow manufacturer’s instructions.

D. Check for proper motor rotation.

3.04 RECEPTACLES

A. Test all receptacles for proper connections and grounding. Use an approved plug-in tester equal to Woodhead 1750 or Hubbell 5200.

3.05 CONTROL CIRCUITS

A. Check all circuits for continuity, proper connection, and proper operations.

B. Set all time delay relays and timers for the desired operations. Record the settings, indicating the relay or timer, its location, and the setting used. Verify all settings with a stopwatch.

3.06 LIGHTING

A. Turn on all lights after lamping them with new lamps take load readings of each circuit with lights on. Submit type-written results to the Owner. Results shall include panelboard number and location, branch circuit number and load served, and amperage reading. Balance phases on each panelboard as closely as possible.

B. Install new lamps in all fixtures just prior to final inspection of the project (just prior to final completion). Support all pendant fixtures with swivel type hangers.

C. Replace any damaged fixture or lens at no cost to the owner. Leave any protective covering on lens until the fixture is installed.

D. Allow H.I.D. lights to remain "ON" for 72-hours to check ballasts as well as lamps. Replace any defective material.

3.07 COMBINATION MOTOR STARTERS

A. Set all motor circuit protectors, all feeder circuit breakers, protective relaying system (as applicable) and all overload relays.

B. Take and record voltage and current (amperage) readings on all feeders and motors to ensure proper phase balance.

3.08 15KV METAL-CLAD INDOOR SWITCHGEAR AND 15KV MEDIUM VOLTAGE OVERHEAD BUS DUCTS

A. Refer to and comply with the requirements of Specification Section 16044 "15kV Metal-Clad Indoor Switchgear and 15kv Medium Voltage Overhead Bus Ducts" of the Contract Specifications.

3.09 CONTINUITY TESTS

A. Perform continuity test on all low voltage conductors (600 volt, and below, wiring system). Continuity test must be performed after wiring is pulled in the conduit system and/or underground electrical system (as applicable). Continuity test must be performed on each conductor between its source and final destination (point of termination to load/device/etc.). Utilize Ohmmeter for this test. Ohmmeter must be set to lowest ohm setting, 10 ohms full scale deflection.

B. Perform continuity test on all medium voltage cables per the requirements of Section 16182 "Medium Voltage Cables" of the Contract Specifications.

3.10 EXISTING TRANSFORMER OIL TESTS

A. Take oil samples of the Owner's existing oil filled transformers where specifically noted on the PLANS. Include all costs associated with the packaging, insurance, and transmission of the transformer oil samples to and from a reputable testing laboratory, and all related expenses.

B. Furnish to the Owner a certified written report for each sample that identifies the transformer from which the sample was taken, the date of the oil sample, and the quantity of PCBs contained in the tested transformer oil sample. Format and number of report copies shall be in accordance with the requirements of Section 01300 and Section 01730 of the Contract Specifications.

C. Transformer oil testing shall be performed by an independent professional testing company specialized in, and well equipped to perform, transformer oil testing.

D. Disposal of existing transformers containing PCB oil:

1. Disposal of existing transformers tested and confirmed to contain PCB oil shall comply with federal, state and local laws and regulations. Disposal of materials containing concentrations of PCB shall be by/at a permitted PCB disposal company possessing permit or approval to perform PCB disposal activities.

2. Furnish to the Owner a manifest or bill of laden of the transport of the PCB oil from the Owner's site to the disposal site, as well as the date of transfer, and the name and company name of the individuals who removed the oil from the Owner's site and transported it to the disposal site.

3.11 MEASUREMENT AND PAYMENT

A. No separate measurement or payment for work performed under this Section. All costs are included in the Base Bid.

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SECTION 17100

PROCESS INSTRUMENTATION AND CONTROL SYSTEM PICS

PART 1 - GENERAL

1.01 SCOPE

A. Provide all labor, materials, and equipment to design, furnish, install, calibrate, test, adjust, and place in operation the facility monitoring and control system as specified herein and as shown on the PLANS.

B. The PLANS and Specifications show and specify those features required to illustrate and describe functional requirements of the monitoring and control system.

C. A single Instrument and Control System Contractor (ICS) shall furnish all services and equipment defined herein and in other Specification sections as listed below under Related Work. These services may include but not limited to furnishing the design, equipment, installation, calibration, checkout, required documentation, maintenance, etc. for the entire instrumentation and control system as specified herein and in Division 17 of the Specifications. The Instrument and Control System Contractor is referred to herein and after (in Division 17 of the Specifications) as the ICS, ICS supplier/firm, or Contractor.

D. The ICS shall also:

1. Terminate and tag all field wiring associated with the process instrumentation and control system shown on the PLANS and specified herein and in other Specification sections listed below under Related Work**.** This includes termination and tagging of instrumentation and control system wiring within, inside and at:

   a. Proposed Main Instrument Control Panel in the proposed Substation No. 1 named as "SUB1-MCP-001" on the PLANS.

   b. Proposed Lighting Contactor Panel in the proposed Substation No.1 named as "SUB1-LC-001" on the PLANS.

   c. Proposed Lighting Control Panel Panel in the proposed Substation No.1 named as "SUB1-CP-LCP1" on the PLANS.

   d. Proposed Telephone System Control Panel in the proposed Substation No. 1 named as "SUB1-CP-TELE" on the PLANS.

   e. Existing Telephone System Control Panel in the existing Administration Building named as "TELECOMMUNICATION ENCLOSURE" on the PLANS.

   f. 12.5kV Medium Voltage Switchgears, 4160V Medium Voltage Switchgears, 480V Low Voltage Switchboards, and other power distribution/control equipment as shown on the PLANS

g. The Heating and Ventilating and Air-conditioning (HVAC) Units

h. All the mechanical equipment

i. I&C wiring Field termination junction boxes.

j. Field mounted Control Stations

k. Field mounted instruments and control/sensing devices such as pressure switches, vibration switches, temperature transmitters, analyzer transmitters, pressure transmitters, level transmitters, limit/position sensing switches, process variable indicators and sensors, machine monitoring sensing devices, etc.

l. All Distributed Control System (DCS) system wiring and cables. Including extension and termination of the Modbus TCP network, fiber optic network, remote I/O wiring, etc.

m. optic network, remote I/O wiring, etc.

n. Battery Monitor for the DC Power Storage, Charging, DC Distribution and Inversion Systems

2. Tag Instrumentation and control wiring/cable and Fiber-Optic cables per the requirements and methodology/scheme outlined in specifications *Section 16200 "Wiring (600 volt and Below) paragraph 3.03 "Wire Tagging Methodology"* and per the most recent wire tagging requirements of Austin Water Utility.

3. Calibrate, set and test the PICS equipment, components, cables, hardware, and software.

4. Provide special additional services during installation, including:

   a. Verifying that the following are furnished and installed:

      1) Correct type size, and number of signal wires with their raceways.

      2) Correct electrical power circuits and raceways.

      3) Correct size, type, and number of PICS related pipes, valves, fittings, and tubes.

   b. Required submittals.

   c. Equipment and ancillaries.

   d. Instructions, details, and recommendations to, and coordination with, all other installation entities for Certificate of Proper Installation.

   e. Certifying readiness for operation.

   f. Starting up.

   g. Testing.

h. Training.

5. For equipment not provided by the ICS, but directly connected to the PICS:

   a. Obtain manufacturer's information regarding installation, interface, function, and adjustment for equipment from the Contractor.

   b. Coordinate with Contractor to allow required interface and operation with the PICS.

   c. Verify that installation, interfacing signal terminations, calibration, and adjustments have been completed in accordance with the manufacturer's recommendations.

   d. Test to demonstrate the required interface and operation with the PICS

   e. Examples of equipment in this category include, but are not limited to the following:

      1) Telephone system equipment

      2) Switchboards

      3) Switchgear

      4) Security System

      5) Process/Mechanical Equipment.

6. Provide equipment, software, and services for the installation of the DCS configuration system at the Engineer's *Austin, Texas* office.

7. Assist Engineer, as specified in applicable DCS subsystem specifications sections, in Applications Software Development which shall be provided by Engineer for the DCS and PCs (as applicable).

E. As shown on the PLANS, certain process areas/buildings on the site have an associated Security System and Telephone system. Each of these individual systems require a fiber optic communication network between the various process areas/buildings and the Administration Building. Refer to the PLANS. As shown on the PLANS, the fiber optic communication network for each of these individual systems may not directly interconnect with the process instrumentation and control system. Regardless, the ICS shall furnish and install the fiber optic communication network between the various process areas/buildings as required, complying with all contract document requirements and make all final connections for complete and functional systems. For clarity, this effort shall include, but not be limited to:

1. Coordination with all responsible parties, i.e. Security System Contractor, Owner, etc., to facilitate proper communication equipment selection, fiber optic cable termination connector quantities/types, patch panel locations in controls panels to address minimum cable bending radius, etc., as required

2. Calculations associated with fiber optic loss budgets for a complete and functional installation

3. Furnishing and installing the fiber optic cable as shown on the PLANS, complete with all cable testing

4. System startup testing, diagnosing, and resolving communication system issues, etc.

1.02 RELATED WORK AND EQUIPMENT SPECIFIED ELSEWHERE

A. Division-16 ELECTRICAL SPECIFICATIONS

B. Division-17: INSTRUMENTATION AND CONTROL SPECIFICATIONS

C. All other division of the Specifications related to the installation of the process mechanical equipment, Heating Ventilating and Air-conditioning equipment, etc. that are related to the operation of the instrumentation and control system.

D. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

1.03 ACCEPTABLE INSTRUMENT AND CONTROL SYSTEM SUPPLIERS AND INSTALLERS (ICS)

As minimum the ICS firm to have the following:

A. The ICS firms shall have in-house capability to prepare all necessary component drawings, system drawings (loop diagrams) and installation, operations and maintenance manuals.

B. The ICS firm shall have in-house capability to coordinate design and selection of all components in the instrument and control system. It is understood that the ICS firm shall understand and review the design of the entire process instrumentation and control system PICS and not just trace the PLANS. It is also understood that the ICS firm shall review all the components, equipment, and software/hardware specifications and prepare detailed purchase orders that will assure the proper features are furnished on each component that will comply with the intent of the Specifications and function as required in the individual system as designed and specified by the Engineer.

C. The ICS firm and the key personnel of the ICS firm that shall be directly engaged in the day-to-day activity of this project shall have experience in manufacturing and installing complete instrument and control systems for water and wastewater facilities that are similar in scope and value as that proposed for this project. At minimum, the experience of the key personnel of the ICS firm assigned to this project shall encompass specific expertise in instrumentation and control systems of water and wastewater facilities in various facets of the project including administration, management, equipment selection, equipment submittal preparation, proper procurement of equipment, instrument and control panel layout and integrated component/equipment arrangement and wiring, equipment installation and procurement, coordination with Owner/Engineer and equipment suppliers, production of detailed installation/loop/ wiring/etc. drawings, ….etc. i.e., the ICS firm inclusive of its key personnel shall have the proper resources for the preparation and installation of all efforts and elements of work required to insure proper system setup, proper system operation, and

successful completion of this project. An acceptable ICS firm shall have the following minimum qualifications:

1. The ICS firm shall have a minimum of five (5) years experience in providing, integrating, installing, testing, and start-up of similar systems as those required for this project.

2. The ICS firm Site Representative shall have a minimum of eight (8) years experience installing similar systems as those required for this project.

3. The ICS firm Start-up and Testing Team Members shall have a minimum of three (3) years experience in testing systems similar to those required for this project.

D. The ICS firm shall own and maintain in its headquarter facility a minimum of 4000 square-ft. of manufacturing space dedicated for layout and manufacturing of control panels and associated wiring and integrated systems. The required square footage of 4000 is manufacturing space only and is exclusive of any office spaces of the ICS firm.

E. The ICS shall maintain a fully equipped office/production facility with full-time employees capable of fabricating, configuring, installing, calibrating, troubleshooting, and testing the system specified herein. Qualified repair personnel shall be available and capable of reaching the facility within a 24 hour period.

F. ICS firms that wish to provide these services on this project shall prepare a qualifications package that shall be submitted to the Owner/Engineer for approval. This qualification package must demonstrate ICS's experience in Paragraphs 1.03A through 1.03E herein, which shall be subject to review and approval by Owner/Engineer. The Owner will make the final determination of whether or not the ICS meets the minimum capabilities, experience criteria, and staff and facility requirements as specified herein. All decisions will be final.

1.04 SPECIAL CONDITIONS

A. All components shall be used in the instrument and control systems shall be new (not used) and the current model produced by the manufacturer.

B. All equipment of a common type shall be the product of a single manufacturer.

1.05 SUBMITTALS

A. General: Do not design, manufacture, or ship any PICS equipment until all related submittals have been reviewed by Engineer. Submit shop drawings and product data in complete functional packages; i.e., submit all shop drawings and product data for a given loop or subsystem together as a functional package. Piecemeal submittals not organized by systems or incomplete submittals for a given loop or subsystem will not be accepted. Drawings shall be neat, legible, and on 2 feet x 3 feet sheets.

B. Comply with the requirements outlined in *Subsection 1.07* (below) *"Special Submittal Requirements.* Additionally, Submit shop drawings in accordance with *Sections 01300 and 01730* of the Contract Specifications and as specified below:

1. Prior to the first shop drawing submittal, provide certification that ICS firm has completed the design and taken into account all interrelationships of the specific instruments proposed; and that the design accomplishes the functions described herein and shown on the PLANS.

2. Loop Diagrams: Prepare loop diagrams in accordance to the format shown on the PLANS.

3. Control Cabinet Wiring and Piping Diagrams.

4. Field Wiring and Piping Diagrams:

5. Ladder Diagrams and Control Schematics: Ladder diagrams shall also include interconnections with remotely located and/or existing devices such as motor starters, control valves, flow loops, etc. These diagrams shall be thorough and complete in all aspects. Diagrams shall present/show all control components, pilot devices, terminal block numbers, wire numbers, etc. that are part of the control logic of a single piece of equipment shall be controlled, yet, are not necessarily located in the main instrument control panel and/or the PLC cabinets. Example: control power transformer of each equipment, phase monitors, protective relays, motor space heater, starter coils, overloads, etc. Diagrams shall show these remote devices along with the actual terminal block numbers, wire number, etc., that are utilized within the remote cabinets/equipment in which they are installed and furnished by others. The ICS firm shall obtain all necessary information from the respective remote equipment supplier and/or existing field sensors/instrument which are scheduled for reuse to properly complete these drawings (such as wiring diagrams from process/mechanical equipment manufacturer, 15kV switchgear manufacturer, 5kV switchgear manufacturer, 480V switchboard manufacturer, HVAC equipment manufacturer, etc.). Prepare ladder diagrams and control schematics in accordance to the format shown on the PLANS.

6. Although typical control schematics are presented on the PLANS for the medium voltage motorized load break switches (refer to the PLANS), the Contractor shall generate specific equipment control schematic drawings (i.e., individual control schematic drawings dedicated for each specific equipment) based upon the typical control schematic, the device identification/tag replacement schedules shown on the PLANS, and the additional requirements described herein. The Contractor generated specific equipment control schematics shall follow the same overall presentation format as the typical equipment control schematics/instrument loops presented on the PLANS. The specific equipment control schematics, complete with all specific equipment/device tags, wire codes, terminal block numbers, (as a minimum, also refer to the additional requirements described herein), etc., shall be generated by the Contractor and included with the project submittals (i.e., prior to equipment purchase) and the "As-Built" drawings. Any Contractor generated control schematic shown as applicable to multiple pieces of equipment shall not be accepted. Prepare ladder diagrams and control schematics in accordance to the format shown on the PLANS.

7. All loop diagrams, ladder diagrams, control schematics, etc., shall be generated with terminal block numbers, wire numbers, rung numbers with unique prefix letter(s) for each equipment diagram/schematic, and rung number references for each contact and be complete in all respects. It is anticipated that all wire numbers cannot be accommodated on the loop diagrams, ladder diagrams, control schematics, etc. format shown on the

PLANS. As a minimum, to facilitate the depiction of the wire numbers on the loop diagrams, ladder diagrams, control schematics, etc., the Contractor shall generate and include uniquely identified alpha-numeric wire codes on the loop diagrams, ladder diagrams, control schematics, etc. The wire codes shall cross-reference tables of wire numbers shown on additional drawings that shall be generated by the Contractor. At minimum, the Contractor shall generate the wire codes and the cross-reference tables which depict the wire numbers associated with each wire code and shall group the cross-reference tables by specific equipment (15kV Switchgear SUB1-SWGR-100, etc.). As a minimum, the Contractor shall generate drawings to depict the wire code and wire tag cross-reference tables and these drawings shall also be grouped by specific equipment (15kV Switchgear SUB1-SWGR-100, etc.). Additional requirements concerning the cross-reference table headings, table organization, wire code generation, formatting, etc., shall be provided by the Owner during the Pre-Submittal Conference specified hereinafter (refer to subsection 1.08, this Section of the Specifications) and the Contractor shall incorporate these requirements at no additional cost to the Owner.

8. Submit detailed product data for each item of equipment and material:

9. Submit four copies of the following reports:

    a. Factory calibration reports.

    b. Installation inspection reports.

    c. Field calibration reports.

    d. Field system test report.

10. Operation and Maintenance (O&M) Manuals:

    a. Content and Format:

        1) Complete sets of separately bound O&M manuals for each PICS Subsystem.

        2) Sufficient detail to allow operation, removal, installation, adjustment, calibration, maintenance and purchasing replacements for each PICS component.

11. Testing Related Submittals: Submit the following for each of type of test required under Division 17 of the Specifications:

    a. Preliminary Test Procedures: Outlines of proposed tests, forms, and checklists.

    b. Final Test Procedures: Proposed test procedures, forms, and checklists.

    c. Test Documentation: Copy of signed off test procedures when tests are completed.

1.06 OPERATION AND MAINTENANCE MANUALS

Furnish and submit Operation and Maintenance manuals in accordance with Section 01300 and 01730 of the Contract Specifications. Additionally, provide Operation and Maintenance

manuals in electronic format per the requirements of Section 01730 of the Contract Specifications. Include approved shop drawing data in the Operation and Maintenance manuals and including the following contents:

A. Information as specified in Paragraph 1.05 with the following modifications to the shop drawing exhibits:

   1. Reflect "As-Built" conditions.

   2. Prints of exhibits, wiring diagrams, etc. shall be half size (11 x 17-inch).

   3. Full size reproducible mylars (2 x 3-foot) of all exhibits, loop diagrams, ladder control wiring diagrams, point to point wiring diagrams, etc. The same must also be submitted on both 3-1/2" floppy diskettes and CD-ROM produced in AutoCAD (latest release)**.**

B. Operating procedures.

C. Shut-down procedures.

D. Safety instructions.

E. Calibration instructions and factory test results of each instrument.

F. Maintenance and repair instructions.

G. Recommended spare parts list.

H. Name, address and phone number of instrumentation control system supplier's local representative.

I. Additionally, comply with the requirements of the Contract Documents.

1.07 SPECIAL SUBMITTAL REQUIREMENTS – APPLICABLE TO BOTH SHOP DRAWING SUBMITTALS AND OPERATIONS AND MAINTENANCE MANUALS:

A. All system layout drawings, cross sectional view drawings, wiring diagram drawings, Connection detail drawings, physical layout and detail drawings, etc. shall be developed electronically using "**AUTO-CAD Version 2007 software".** Submittals shall include hard copies (of the quantity and format required by the Contract Documents) and electronic Version in "**AUTO-CAD Version 2007";** This applies to all drawings requested in this Section of the Specifications and any other manufacturer's product standard drawings required for submittal, and <u>ALL PRODUCT DRAWINGS TO BE SUBMITTED</u> for this project. Electronic Version shall be submitted in a CD-ROM.

B. All system equipment and associated component Bill of Material sheets and/or tables indicating product data, quantities, physical location and reference, catalog number, wire tags, reference, wiring diagram drawing number reference, cost, and any other field entered in the bill of materials sheet and/or any other spreadsheets and/or any other table and/or listings of references/etc. <u>SHALL ALL BE ELECTRONICALLY DEVELOPED IN A DATABASE FORMAT</u> using **MICROSOFT ACCESS - 2000 Software** (professional

suite). This applies to all summary sheets, material listings, etc. TO BE SUBMITTED for this project. Submittals shall include hard copies (of the quantity and format required by the Contract Documents) and an electronic Version developed in **MICROSOFT ACCESS - 2000**. Electronic version shall be submitted in a CD-ROM.

C. AUTOCAD drawings shall be developed in full adherence to the formats and drawing standards developed by the City of Austin. A copy of the AUTOCAD DRAWINGS STANDARDS MANUAL SHALL BE OBTAINED FROM **AUSTIN WATER UTILITY**.

1.08 PRESUBMITTAL CONFERENCE

A. Schedule, arrange and conduct a presubmittal conference for the entire PICS within 90 days after receipt of written notice to proceed work is given by the Owner.

B. The presubmittal conference shall be attended by representatives of the Contractor, the Engineer and the ICS firm. Each attendee to allot time required for the conference.

C. The purpose of the presubmittal conference shall review the manner in which the Contract requirements will be met before any submittals are prepared.

D. The following items shall be presented at the presubmittal conference:

1. A list of equipment and materials required for the PICS and the brand shall be used for each item.

2. A sample of each type of submittal specified later herein.

3. Sample submittal drawings from similar projects previously performed by the ICS firm. Submittal drawings shall include sample wiring diagrams, cabinet elevations, bill of materials, etc.

PART 2 - QUALITY ASSURANCE

2.01 ACCEPTABLE PROCESS INSTRUMENTATION AND CONTROL SYSTEM PICS

A. Provide a complete, workable, and installed-in-place Instrument and Control System, hereinafter referred to as the PICS, as specified herein. The PICS shall be designed, installed, and started up by the single ICS firm.

B. Acceptable ICS firm shall be as required by *Subsection 1.03, above*.

2.02 SYSTEM COORDINATION AND QUALITY

A. Coordinate installation of instrumentation with mechanical and electrical systems.

B. Coordinate subsystems to provide a complete operational and functional instrumentation system to the satisfaction of the Owner and Engineer.

C. Equipment, instruments, components, and materials for PICS components shall be new (not used) and of the current model.

D. Instrument and Control Components Furnished By Others: Certain items of instrumentation and controls shall be furnished by various equipment manufacturers. Coordinate the purchase orders of the items such that the resulting system will function properly.

2.03 DESIGN CRITERIA

Design, construct, and install all PICS components in compliance with the applicable provisions of the following standards, codes, and regulations:

A. American National Standards Institute (ANSI) Standards.

B. American Institute of Steel Construction (AISC) Standards.

C. American Society for Testing and Materials (ASTM) Standards.

D. American Waterworks Association (AWWA)Standards.

E. Joint Industrial Council (JIC) Standards.

F. National Electric Code (NEC)

G. National Electrical Manufacturer's Association (NEMA) Standards.

H. Local and State Building Codes.

I. Occupational Safety and Health Administration (OSHA) Regulations.

J. Scientific Apparatus Manufacturer's Association (SAMA) Standards.

K. Instrument Society of American Standards (ISA).

L. Institute of Electrical and Electronics Engineers (IEEE).

2.04 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Delivery: Enclose cabinets and subassemblies in heavy polyethylene envelopes to protect them from dust and moisture. Place corrosive-inhibitive vapor capsules in shipping containers, and related equipment as recommended by the capsule manufacturer.

B. Storage: All materials and equipment shall be environmentally protected and stored in climate controlled (temperature and humidity, etc.) environment. The Main Instrument Control Panel (designated on the drawings as “SUB1-MCP-001”) and the field control and instrument/monitoring panels shall not be moved from climate controlled storage room to the project site until the construction of the electrical/control room is completed, and, the air-conditioning and heating system of the Substation No. 1 Building is in satisfactory operating condition to the Owner and Engineer.

2.05 CALIBRATION INSTRUMENTS

Each instrument used for calibrating PICS equipment shall bear the seal of a reputable laboratory certifying that instrument has been calibrated within the previous twelve (12) months to a standard endorsed by the National Institute of Standards and Technology (NIST).

2.06 PICS WARRANTY

Start Date of the process instrumentation and control system and associated subsystem Warranty (PICS including Subsystems) shall commence after owner acceptance of the process instrumentation and control system and after the final completion date for the overall project per the requirements of the Contract Documents or a minimum. The duration of the warranty shall be a minimum of two (2) years.

PART 3 - SEQUENCING AND SCHEDULING

3.01 GENERAL

A. All work provided under this section shall be in accordance with the Engineer-approved Schedule of Submittal Submissions and Schedule of Values.

B. Specification and Construction Implementation Plan *shown on the PLANS* requires phased installation of equipment and systems.

C. Wherever language in this section refers to the "PICS", the entire installed PICS, the entire PICS, or similar language, it shall be interpreted to apply to the individual phases of the work; except the requirements for the Performance Acceptance Test PAT.

3.02 SCHEDULE OF VALUES

A. Purpose: Project Schedule of Values and Progress Schedule to provide a basis for Partial Payment for Work completed.

B. Content: Summary of major milestones and associated Partial Payments for Work provided under PICS Subsystems.

3.03 PICS COMPLETION

A. When Engineer issues Certificate of PICS Completion.

B. Prerequisites:

1. All PICS submittals have been completed

2. PICS has successfully completed PAT.

3. Owner training plan is on schedule.

4. All spares, expendables, and test equipment have been delivered to Owner.

3.04 PICS ACCEPTANCE

A. When Engineer issues a written notice of acceptance.

B. Prerequisites:

1. Certificate of PICS Completion issued for the Construction Contract per the requirements of the Contract Documents.

2. Instrument Installation Reports "IIR" are completed, and all deficiencies are corrected.

3. Performance Acceptance Test PAT is completed

4. Punch-list items completed. NOTE: punch list items will be issued 15 Calendar days following completion of the PAT.

5. Final revisions to O&M manuals accepted.

6. All Training is completed

3.05 PREREQUISITE ACTIVITIES AND LEAD TIMES:

A. Start following key Project activities when prerequisite activities and lead times listed below have been completed and satisfied:

Activity	**Prerequisite and Lead Times**
Submittal reviews by Engineer	Engineer acceptance of Schedule of Values and Progress Schedule and completion of the Pre-Submittal conference
PICS hardware purchasing, fabrication, and assembly	Associated shop drawing submittals completed
DCS system design, fabrication and assembly	Associated shop drawing submittals completed
All remaining PICS instruments, components, hardware, fabrication, assembly, etc.	Associated shop drawing submittals completed
Shipment	Completion of PICS shop drawing submittals, preliminary O&M manuals
Performance Acceptance Tests PAT	Application software completed by Engineer and configuration system

Activity	Prerequisite and Lead Times
	shipped from Engineer location to the project site, and the Instruments Installation Report(s) "IIR" completed, and PICS On-Site Demonstration Tests completed, and Contractor letter notification of successful completion of PICS On-Site Demonstration Test and Contractor's readiness for commencement of PAT is submitted. Additionally, the Startup and PAT procedures associated shop drawing submittals must be completed. Note: Owner requires Four (4) weeks notice prior to start PAT.
Owner training	Completion of PAT.

PART 4 - PRODUCTS

4.01 GENERAL

Refer to requirements of PICS Subsystem provided in Division-17 Specifications.

4.02 SOURCE QUALITY CONTROL

A. General:

1. Test all PICS elements, both hardware (instruments, components, devices, PLCs, etc.) and specific software, to demonstrate that PICS satisfies all requirements.

2. On-Site Tests Described Under PART 5 - EXECUTION:

   a. Performance Acceptance Tests "PAT".

3. Procedures, Forms, and Checklists:

   a. Conduct all tests in accordance with, and documented on, Engineer accepted procedures, forms, and checklists.

   b. Describe each test item to be performed.

   c. Have space after each test item description for sign off by appropriate party after satisfactory completion.

4. Required Test Documentation: Test procedures, forms, and checklists. All signed by Owner/Engineer and Contractor.

5. Conducting Tests:

    a. All special testing materials and equipment.

    b. Wherever possible, perform tests using actual process variables, equipment, and data.

    c. If it is not practical to test with real process variables, equipment, and data, provide suitable means of simulation.

    d. Define simulation techniques in test procedures.

6. Owner/Engineer will actively participate in many of the tests.

7. Owner/Engineer reserves the right to test or retest all specified functions whether or not explicitly stated Test Procedures.

8. Owner's/Engineer's decision will be final regarding acceptability and completeness of all testing.

PART 5 - EXECUTION

5.01 EXAMINATION

A. Equipment furnished by Supplier or any other subcontractor and installed by the ICS requires Supplier to observe and advise on installation to extent required to certify that equipment has been properly installed and will perform as required.

B. For equipment not provided by Supplier, but that directly interfaces with the PICS, verify the following conditions:

    1. Proper installation

    2. Calibration and adjustment of all instrumentation and control devices.

    3. Correct control action.

    4. Switch settings.

    5. Opening and closing speeds and travel stops.

    6. Input and output signals.

5.02 INSTALLATION

A. General:

1. Install all equipment in accordance with the PLANS and instructions furnished by the manufacturer. Inspect each new instrument, control component, etc., before installation. Replace deficient items.

2. Instruments Installation Report(s) IIR: After installation, the manufacturer's non-sales type technical representatives shall inspect the installation and prepare a report or reports to include the following:

   a. A list of all deficiencies found.

   b. Recommended corrective action for all facilities.

   c. Certification that the item or system is properly installed, calibrated and tested except as noted.

3. The IIR shall be prepared for the following instruments:

   a. Analyzer Indicators/Transmitters.

   b. Intelligent Temperature Measuring Indicators/Transmitters.

   Note: The IIR is required in addition to all the other tests, calibration and checkout procedures required under Subsection "Field Quality Control" (of this Section), and other similar requirements identified in all PICS Subsystems Specifications (Division-17, at its entirety). The IIR must be completed and all deficiencies must be corrected by the ICS prior to commencing the PAT.

B. Wiring:

1. All wiring connected to PICS components and assemblies including shall be in accordance to the requirements of Division 16 and 17 of the Specifications.

5.03 FIELD QUALITY CONTROL

A. General: All requirements listed in Subsection Source Quality Control above, also applies to this Subsection Field Quality Control.

B. Onsite Supervision:

1. The ICS Project Site Representative to supervise and coordinate all onsite PICS activities.

2. The ICS Project Site Representative shall be On-Site during total period required to complete all On-Site PICS activities.

C. Startup and Testing Team:

1. Startup and Testing Team will consist of ICS firm and equipment supplier non-sales type technical representatives. The entire Process Instrumentation and Control System PICS shall be tested together.

2. Thoroughly check installation, termination, and adjustment for all PICS Subsystems and their components.

3. Complete On-Site tests.

4. Complete On-Site training.

5. Provide and conduct startup services.

6. PICS On-Site Demonstration Tests: Prior to startup of the Performance Acceptance Test "PAT", the ICS firm shall test the PICS equipment and systems:

    a. Conduct the On-Site Demonstration Tests with entire PICS installed to demonstrate that it is operational and interconnected.

    b. PICS Subsystems: each portion of the PICS Subsystem shall be tested. (entire system interconnected).

    c. DCS Loop-Specific Functions including discrete, analog, etc..

    d. Loop-Specific Functions for Remaining PICS Subsystems including discrete, analog, etc.

    e. Make following documentation available to Owner/Engineer at test site both before and during the tests:

        1) Master copy of On-Site Tests Procedures.

        2) List of equipment to be tested including make, model, and serial number.

        3) Shop Drawing hardware and software submittals for equipment being tested..

    f. Daily schedule for the Test:

        1) Begin each day meeting to review day's test schedule.

        2) End each day with each meeting to review day's test results and to review or revise next day's test schedule.

7. During the PICS On-Site Demonstration Tests, the Contractor shall maintain a list, henceforth called the PICS On-Site Demonstration Tests Corrective Action List, that identifies, with a detailed description, each problem found, the affected equipment, and the corrective measures taken to correct each problem. The Contractor shall submit the PICS On-Site Demonstration Tests Corrective Action List for review if requested by the Owner and shall submit the PICS On-Site Demonstration Tests Corrective Action List within seven calendar days of the requested date. The Contractor shall claim and validate thorough PICS On-Site Demonstration Tests were performed successfully and all resulting corrective action measures taken were performed successfully and re-tested successfully. Upon successful completion of the PICS On-Site Demonstration Tests, the Contractor shall submit letter notification to the Owner stating that all PICS On-Site Demonstration Tests have been successfully completed. The letter notification shall further state that the ICS is ready to begin the Performance Acceptance Test.

D. Performance Acceptance Tests "PAT":

1. Minimum duration of the PAT shall be a cumulative total of fifty (50) calendar days. The cumulative total quantity of calendar days shall be consumed in association and in synch with the overall construction sequence for the project. Similarly as described in the overall project construction sequencing requirements, it is anticipated that the PAT associated with certain areas such as the Substation No. 1 Building and the Chemical Building area could not occur simultaneously, please refer to the overall project construction sequencing requirements and remaining contract documents. Any Holidays that occur during the PAT shall result in a corresponding number of days being added to the duration of the PAT. The PAT encompasses startup and testing period of the instrumentation and control system and the associated process and mechanical equipment that are controlled and monitored by the instrumentation and control system. The PAT shall be conducted using application software developed by the Engineer. The ICS shall test functions installed and the hard-wired system and the entire associated instrumentation and control system including validating the operation and monitoring and control functions of the all instruments, all control devices, all instrument and control components, control functions, alarm function, monitoring function, calibration ranges, control/alarm setpoint operations, etc. Owner/Engineer shall test software functions. The ICS shall also test the DCS.

2. Commissioning of PICS and Facility in General: The facility and the PICS along with the associated process and mechanical equipment shall not be considered ready for operation and commissioning until the PAT is successfully completed and it is completed to the satisfaction of the Owner/Engineer.

3. The ICS shall startup and test the operation of the instrumentation and control system and the operation of the associated process and mechanical equipment that shall be monitored and controlled by the instrumentation and control system. The ICS shall demonstrate that the PICS is operating as required by the Contract Documents. Demonstrate each required function on a paragraph-by-paragraph, loop-by-loop, point-by-point basis, function by function basis, event by event basis, control function by control function basis, step by step logic test basis, etc.

4. Loop specific tests except that the entire installed PICS tested using actual process variables and all functions demonstrated, as minimum.

a. Check the PICS for proper installation, calibration, and adjustment on a component-by-component basis.

b. Use Loop Status Report to organize and track inspection, adjustment, and calibration of each loop.

c. Calibrations, Setting and Testing, for example, but not limited to:

1) Analog and Sonic-Echo Devices: Actual inputs and outputs at 0, 10, 50, and 100 percent of span, rising and falling.

2) Discrete Devices: Actual trip points and reset points.

3) Indicators/Transmitters/Controllers: alarm and control set point as well as setpoint function tests in association with their respective interface with the control logic of the associated process mechanical equipment.

4) Closed and open loop PID type control algorithms.

5) I/O Modules: Actual inputs or outputs of 0, 10, 50, and 100 percent of span, rising and falling

5. Maintain Loop Status Reports, Valve Adjustment Sheets, and Component Calibration Sheets at Project site and make them available to Owner/Engineer at all time. The ICS shall develop project specific Loop Status Reports, Valve Adjustment Sheets, and Component Calibration Sheets and submit a sample report of each type for review by Owner/Engineer at least 60 Calendar days prior to commencing the PAT.

6. Perform local and manual tests for each loop before proceeding to remote and automatic modes.

7. Complete control logic simulation and actual/live test in all modes of operations.

8. Make updated versions of documentation required for PAT available to Owner/Engineer at Project site, both before and during tests.

9. Make one copy of all O&M manuals available to Owner and Engineer at the Project site both before and during testing.

10. The Owner and/or Engineer shall witness all Tests.

11. The PAT shall be completed in coordination with the Owner/Engineer and the ICS firm.

12. Final Maintenance Report: Summarizing maintenance performed during PAT:

a. Tasks performed and person-hours required for the performance.

b. Numbers and types of components repaired or replaced, name and address of repair firm, extent of repairs, and time required for their completion.

c. Recommended additional components, test equipment, tools, and other facilities for maintenance not supplied under this contract.

5.04 MEASUREMENT AND PAYMENT

A. No separate measurement or payment for work performed under this Section. All costs are included in the Base Bid.

END OF SECTION

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SECTION 17200

INSTRUMENTATION AND CONTROL CABINETS AND ASSOCIATED EQUIPMENT

PART 1 - GENERAL

1.01 SCOPE

A. This Section covers the instrument and control cabinets that shall be furnished, installed, and put into satisfactory service which at minimum includes the following:

1. Large freestanding type of cabinet named as "SUB1-MCP-001" is required in the proposed Substation No. 1 Electrical Substation Building at the South Austin Regional Wastewater Treatment Plant. Refer to the PLANS.

2. Wall/Rack/Bracket/Channel mounted type cabinet named as "SUB1-LC-001" is required in the proposed Substation No. 1 Electrical Substation Building at the South Austin Regional Wastewater Treatment Plant. Refer to the PLANS.

3. Wall/Rack/Bracket/Channel mounted type cabinet named as "SUB1-CP-LCP1" is required in the proposed Substation No. 1 Electrical Substation Building at the South Austin Regional Wastewater Treatment Plant. Refer to the PLANS.

4. Wall/Rack/Bracket/Channel mounted type cabinet named as "SUB1-CP-TELE" is required in the proposed Substation No. 1 Electrical Substation Building at the South Austin Regional Wastewater Treatment Plant. Refer to the PLANS.

1.02 RELATED REQUIREMENTS

A. Refer to Section 17100

B. Related work as called for on the PLANS, as specified herein or in other Sections of the Specifications.

1.03 SUBMITTALS

A. Submit the following in accordance with the *Section 01300 and Section 01730* of the Contract Specification and Specification *Section 17100:*

1. Shop drawings and product data.

2. Operation and maintenance manuals.

1.04 TOOLS AND SPARE PARTS

A. Furnish the following spare parts with the equipment for each Main Instrument and Control Cabinet (MCP) in conformance with the specifications:

1. One set (minimum 3) of Circuit Breaker Overcurrent Protection Devices for each type and size used.

2. Twenty (20) terminal blocks of each color and type used.

3. Four (4) control relay assemblies for each type specified. Each assembly shall be fully assembled and furnished complete with:

   a. The relay coil,

   b. Four(4) Normally Open (N.O.) contacts, and

   c. Four(4) Normally Closed (N.C.) contacts.

   d. Relay Manufacturer's Transient Voltage Suppression Module.

4. Four (4) Timing relays, each complete with the relay socket base assembly.

5. Four (4) complete single input single output Instrument Loop Current Isolators (I/I Converters).

6. Four (4) complete single input dual output Instrument Loop Current Isolators (I/I Converters).

7. 25% spare push-buttons, selector switches, indication light assemblies for each type used (minimum of 2 per type).

8. 50% of spare lenses and lamps for each type and color size and type used (minimum of 4 per type).

1.05 STORAGE AND HANDLING

A. Upon delivery to the project site and prior to final installation, protect and store in accordance with the following:

1. Environmentally protected and stored in climate controlled (temperature, humidity, and non-corrosive class) environment at the job site. Size, furnish and install temporary gaseous air scrubbers, air conditioners, and additional environmental control equipment complete with branch circuiting conduit/wire as required to maintain in a controlled environment at the following conditions:

   a. Ambient Dry Bulb Temperature:

      1) Minimum: 68 degrees Fahrenheit.

      2) Maximum: 85 degrees Fahrenheit.

b. Ambient Relative Humidity: Maximum: 50%.

c. Ambient Corrosion Level: International Society of Automation Class: G1

2. Every effort shall be made to provide all necessary electrical power connections ready for immediate connection to equipment upon arrival of equipment on jobsite.

3. Upon arrival of equipment onto job site, a maximum of one day shall be allowed for equipment to be left without to allow proper transition of power of equipment, especially any 120 VAC powered equipment, to ensure all air conditioning, heating, and gaseous air scrubbing equipment are fully operational with a maximum of a 10 minute down time during this transition of power.

4. Furnish and install replacement air scrubber media, air filters, etc., as required for proper operation of the environmental control equipment.

PART 2 - PRODUCTS

2.01 GENERAL CONSTRUCTION REQUIREMENTS FOR INSTRUMENT AND CONTROL CABINETS/PANELS

A. The various instrument and control cabinets/panels shall be constructed to the approximate dimensions and instrument arrangement as shown on the PLANS. The Engineer will review alternate arrangements and recommendations.

B. Cabinet doors shall be provided in the locations shown on the PLANS. Cabinets shall have door in front and instruments mounted on front face of cabinet. All instruments, devices and wiring shall be arranged such that everything can be installed, removed and serviced through the door. Cabinets shall be of the approximate size as shown on the Plans. Alternate arrangements of equipment will be reviewed by Engineer upon recommendations (if any) by the manufacturer.

C. Wire entering the cabinets shall enter through the floor, the side and/or the top of the cabinets via conduits with bushings or hubs. All wiring shall be terminated on terminals located on an interior panel prior to being connected to any instrument or switch. All internal wiring shall be accomplished by the **ICS** prior to shipment. All wiring and terminals shall be clearly marked and wiring schematics furnished. All wiring shall be neatly bundled, laced together and routed as required throughout the cabinet.

D. The exterior of each panel shall be painted *Medium Gray with textured finish*. However, Manufacturer furnished samples of the specified paint color and finish, in addition to other available paint colors and finishes shall also be submitted for final selection by the Owner.

E. Cabinet doors shall have heavy gauge continuous hinges. Hinges and doors shall be capable of supporting weight of equipment mounted on doors.

F. Mounting channels and interior panels shall be provided in the cabinets for mounting terminals, relays, etc.

G. The cabinet shall be completely assembled and wired at the factory such that installation can be accomplished by connecting field wiring to terminal strips located in the panel.

H. Each cabinet section shall be furnished with a minimum of two (2) ground buses/bars, isolated and non-isolated ground bars. Exception: Only non-isolated ground bars are required in "SUB1-LC-001", "SUB1-CP-LCP1" and "SUB1-CP-TELE". The isolated ground wiring ground buses/bars shall be supported/bolted to the control cabinet through 600 volt isolators. Each ground bus/bar shall be furnished with the required number of terminals for proper wiring in addition to 20% spare terminals for future connections. Do not connect/terminate more than one (1) isolated or distorted ground wire to a single terminal point on a ground bar/bus. Certain microprocessor based control equipment will require the connection of both distorted and undistorted (isolated) ground wires such as Programmable Logic Controllers **PLC's, PLC** Input/Output **I/O** cards, Fiber Optic Communication equipment, etc.

I. Instrumentation and Control equipment installed in the cabinets that require isolated/clean (undistorted) ground wire terminations (in addition to distorted ground wire termination) shall be supported/bolted to the control cabinet through 600 volt isolators (i.e., electrically isolated from body/housing of control cabinets and distorted ground wires). As minimum, this requirement applies to the Programmable Logic Controllers **PLC's, PLC** Input/Output **I/O** cards, etc.

J. Mark all wiring (power, control, instrument, alarm, data, ground, shield, etc.) at each end of each wire. Use Flame-Retardant, Heavy-Duty Industrial Grade and Heat Shrinkable type wire tags approved for this use and as manufactured by **"Raychem type Heave-Duty Industrial Grade ShrinkMark Heat-Shrinkable Marking Sleeves"**. All wire tags shall be **YELLOW** in color ***Except the color*** *used for branch-circuit lighting, convenience receptacle circuits, and 120 volts AC power circuits to instrument/devices shall be* ***WHITE***. HEAT SHRINK ALL WIRE TAGS. All wire tags must be typed with an indelible marking process. Utilize **"Raychem" Portable-Marking-System" complete with wire tag cartridges.** Character size shall be minimum of 1/8" in height. Handwritten tags WILL NOT BE ACCEPTED. Minimum length of each wire tag shall be 2-inches long. Tag each wire in a Multi-Conductor cable in addition to the overall cable itself. Heat shrink all wire tags. Wiring must be tagged the same as the terminal block terminal designation. Wiring of each equipment (such as Substation No. 1, 15kV Switchgear, Automatic Transfer Switch, HVAC unit, etc.) within the facility must be tagged different from any other equipment, and easy to identify even without schematic drawings at hand. Power, Control and Instrumentation wiring/cable tagging shall be per the requirements and methodology/scheme outlined in specifications Section 16200 "Wiring (600 volt and Below) paragraph 3.03 ***"Wire Tagging Methodology".***

K. Each piece of equipment shall have its individual control wiring terminal block/strip segregated and isolated from terminal block/strip of any other equipment. Example: Control wiring terminal block/strip for the 15kV Switchgear "SUB1-SWGR-100" shall be physically isolated and mechanically separated from terminal block/strip utilized for control wiring of 15kV Switchgear "SUB1-SWGR-200"; i.e., one long and continuous terminal block/strip for both equipment and/or any other equipment (such as Automatic Transfer Switch "SUB1-ATS-001", HVAC unit, etc.) will not be accepted. Additionally, signal wiring to **PLC** cabinet/racks shall be terminated to terminal blocks/strips segregated and isolated from

terminal blocks/strips of any other equipment. This requirement also applies to discrete and analog signal wiring to multiple remote instrument and control panels/cabinets.

L. Install 1-1/2-inch high heavy duty fiberglass floor grading at the bottom of each section of the freestanding instrument control cabinets/panel. Each floor grading to be removable, however secure each to the bottom beams of the cabinet with stainless steel bolts/hardware. The fiberglass grading shall form a continuous floor allowing maintenance personnel to walk inside the cabinet/panel, from one section to another without exiting the cabinet/panel. The floor grading shall meet **OSHA** safety standards for personnel traffic. Field instrument /control/power/etc. wiring and cable entering/exiting the cabinets/panels shall be neatly laced/arranged beneath the fiberglass grading; i.e., the grading must be installed after start-up and testing is successfully completed.

M. The interior of the cabinets shall be painted white.

N. Backpanels shall be painted white. Each section of the freestanding control cabinet/panel shall be furnished with a backpanel that shall extend the full height and width of the respective section.

2.02 MAIN INSTRUMENT AND CONTROL CABINETS

A. Freestanding Cabinets/Panels in the proposed Substation No. 1 (Cabinet named on the PLANS as "SUB1-MCP-001"):

1. Instrument and control cabinets that are freestanding shall comprise of the manufacturers MODULAR ENCLOSURES completely enclosed metal cubicles from formed structural members and furniture steel plate. The modular enclosures shall be joined together to form the overall freestanding cabinet (line-up). The cabinets shall comply with **NEMA-12** gasketed enclosure standards and be constructed of metal not less than **12 gauge** thickness. Provide lifting eyes for easy handling. Door shall be provided with neoprene door gaskets attached with oil-resistant adhesive and held in place with steel retaining strips. Doors to have a continuous piano type hinge. Provide a 3-point latching mechanism, operated by an oil-tight key- locking handle on each door and on each set of overlapping doors. Provide rollers on the end of the door latch rods for easier door closing.

2. The cabinets shall be of the MODULAR design with SINGLE frame cabinet assemblies. Also, comply with the requirements of the PLANS.

3. The manufacturers modular enclosure design shall also be of the type that is specifically manufactured to accept a wide variety of, USER SELECTABLE, manufacturer's **Internal *and* External Components** for configuring/arranging the freestanding cabinets as desired in order to achieve ease of maintenance for devices mounted within the cabinets, practical installation, space savings, aesthetics, etc. As minimum the following components must be available and be manufactured by the same manufacturer, and shall be utilized in the installation of each section of the MODULAR ENCLOSURES, unless otherwise noted:

   a. TOPS and BASES - External Components

1) Tops shall be solid. Tops shall be furnished with removable lifting eyes. Bases shall be either solid or shall have adequate window openings for bottom conduit system entry. Refer to the PLANS. All bases shall be equipped with Stabilizers to provide extra stability for the enclosures. The exact dimensions of the window opening shall be determined based on the magnitude/spacing of the conduits entering the bottom of the cabinets.

2) The height of the solid bases shall be a minimum of 5-inches and a maximum of 9-inches. The exact height shall be determined based on the volume of field interconnect cables/wiring. The cost of either arrangement shall be included in the BASE-BID. ***Please Note:*** All sections of the cabinet shall have the same height.

3) Tops and bases shall be painted a different color from the enclosure body for architectural appearance. Additionally, the tops shall have a manufacturer's TRIM for architectural appearance.

4) The tops shall be equipped with EXTRA SUPPORT BRACKETS to provide the extra support needed to accommodate the TOP ENTRY CONDUIT SYSTEM.

b. SIDE and BACK COVERS - External Components

1) Solid side cover shall be utilized for the end sections of the cabinet line-up. Each side cover shall be of one piece extending the full height and depth of the enclosure.

2) Solid back cover shall be provided for each section of the cabinets. Each back cover shall be of one piece extending the full height and width of the enclosure.

c. DOOR ASSEMBLIES - External Components

1) Each section of the cabinets shall be furnished with a Full Height Solid Door. DOUBLE-BAY modules shall be equipped with two(2) overlapping doors.

2) As indicated above, each door shall be equipped with a piano type hinge extending the full height of the enclosure.

3) As also indicated above, each door shall be equipped with 3-point latching mechanism and a key-lockable door handle. Door handles shall rotate clockwise or counterclockwise. Door handles shall be available in Medium Gray or Black colors for final selection by the OWNER.

4) Each door assembly shall be furnished with manufacturer's Door STOP Kit that will enable hold the door open in any position between 0-140 degrees.

5) Each door assembly shall be furnished with the manufacturer's Full-Door-Height **DOOR BARS** for the installation of inner device panels, rack-grid-system, etc. Each door MUST BE EQUIPPED WITH DOOR BARS EVEN WHEN DOOR MOUNTED DEVICES ARE NOT REQUIRED BY THE PLANS AND SPECIFICATIONS.

6) The inside of each door shall be equipped with the manufacturer's DATA-POCKET for storing drawings and manuals. Double-Bay enclosures shall be furnished with one (1) data-pocket.

7) Doors that are scheduled to have a door mounted device/instrument shall also be equipped with manufacturer's GRID-STRAPS and FASTENER PACKAGE that shall be installed horizontally between DOOR BARS.

8) Each door shall be furnished with the cabinet forced air ventilation assembly comprised of manufacturer's door mounted and thermostatically controlled EXHAUST FAN and associated LOUVER, and DOOR MOUNTED FRESH AIR INTAKE Louver, as also detailed on the PLANS. Each exhaust fan shall be of fractional horsepower with an operating voltage of 120 volts AC. Thermostats shall be mounted on the backpanel assembly of the cabinets. The thermostat shall be equipped with temperature gauge and temperature setting dial with setpoint indicating gauge. Thermostat shall be as manufactured by **Honeywell, Johnson Controls**, or approved equal. Fans shall be mounted on the inside of each door. Connect exhaust fans to the same circuitry as the 120 volts AC lighting and receptacle circuitry in the cabinets. Provide an isolation DIN-RAIL mounted isolation circuit breaker for each exhaust fan. Size the circuit breaker per the National Electric Code (N.E.C.).

d. BACKPANELS (Subpanels) - Internal Components

1) Each section of the cabinet (modular-bay) shall be furnished with a full and solid backpanel (one piece full subpanel). Each backpanel shall extend the full height and width of the section.

2) Backpanels shall be used for mounting device terminals, relays, wireways, etc.

3) Each backpanel shall be mounted on the manufacturer's DIN Frame which shall be an inner frame around the full inner height and inner width of the section (BAY).

4) In addition to the backpanels, install a JOINING-BACKPANEL (joining subpanel) between every two (2) backpanels to provide a continuous backpanel (subpanel) surface between all the section.

5) All backpanels and joining backpanels shall be painted **WHITE**.

e. Accessories - Internal Components

The following represent only the bare -minimum accessories, other hardware type and component installation type accessories shall also be included and provided to accommodate for the neat, safe, aestheticly pleasing installation. Adherence to this requirement is necessary in order to accomplish a good craftsmanship-like system installation in an effort to and to the satisfaction of the OWNER and ENGINEER. The bare -minimum accessories required are:

1) Each door shall be electrically bonded to the frame of the associated enclosure with #8 AWG 600 volts insulated GREEN ground wire. Utilize manufacturer's grounding device assembly.

2) Install manufacturer's DRAW-OUT SHELVES for mounting equipment on a horizontal plane to reduce from consumption of vertical space as well as providing a more convenient and easy access to the devices by maintenance personnel. The shelf assemblies shall be of the HEAVY-DUTY draw-out type with guide rails. As minimum Draw-out shelves shall be utilized for mounting the data communication protocol converters and their associated power outlets and power adapters, transceivers, Bridge-Muxs', and Instrument loops redundant DC power supply unit(s). Additionally, refer to the additional requirements of the PLANS. Draw-out shelves and associated assemblies shall be painted **WHITE**.

4. Freestanding Cabinets/Panels cabinets shall be as manufactured by "Hoffman" Model Proline Modular Industrial Enclosures complete with specified accessories, or approved equal.

5. Folding Shelf: were shown on drawings, furnish and install Folding Shelf as part of the control panel. The shelf shall be 18" x 18", Model # AASHLF1818, as manufactured by Hoffman, or approved equal. The shelf shall be colored White.

B. Wall/Rack Mounted Cabinet/Panel for the lighting contactor panel named on the PLANS as "SUB1-LC-001", lighting control panel named on the PLANS as "SUB1-CP-LCP1", and for the Telephone System control panel named on the PLANS as "SUB1-CP-TELE":

1. Enclosure shall be NEMA-12 dustight/oiltight. Enclosure shall be equipped with hinged doors complete with 1/4 (quarter) turn door latches. Provide door latch handle.

2. Enclosure door assembly shall be furnished with manufacturer's door stop kit that will hold the door open in any position between 0-130 degrees. The door shall be electrically bonded to the frame of the associated enclosure with #8 AWG 600 volts insulated green ground wire. Utilize manufacturer's grounding device assembly. The inside of the door shall be equipped with the manufacturer's data-pocket for storing drawings and manuals.

3. Enclosure shall be furnished with a full and solid backpanel (one piece full subpanel). The backpanel shall extend the full height and width of the cabinet.

4. Cabinet manufacturer's additional hardware and component accessories shall also be provided that will result in a neat, safe, aesthetically pleasing installation. Adherence to this requirement is necessary in order to accomplish a good craftsmanship-like system installation to the satisfaction of the Owner and Engineer.

5. Enclosure shall be as manufactured by "Hoffman" model Concept series industrial enclosures complete with specified accessories, or approved equal by "Rittal".

6. The minimum anticipated panel size for the lighting contactor panel and for the telephone system control panel is shown on the PLANS. The Contractor shall size each panel per the requirements of the NEC. Contractor to determine exact as-built size required for each cabinet to meet the contract documents (drawings and specifications)

without any additional cost to the Owner (should the final size be larger than that which was anticipated by the PLANS). Additionally, the Contractor is to carefully review the electrical/control floor plan drawing and make any adjustments/equipment rearrangements necessary to meet National Electrical Code requirements and any other safety codes adopted by the City of Austin should the cabinet size be any greater/larger than the minimum size required by the PLANS. Conduit/wiring, etc. adjustment caused by any equipment rearrangement, etc. shall also be provided at no additional cost to the Owner.

7. Additional devices are required to be installed inside of the proposed lighting contactor panel and inside the telephone system control panel that are not described in this Section of the Specifications. Furnish and install these devices as required by the PLANS. Refer to the PLANS.

2.03 INSTRUMENT AND CONTROL CABINET INTERIOR LIGHTING AND PROTECTIVE DEVICES

A. 120 Volts A.C. Overcurrent Protection:

1. Each cabinet uninterruptible power supply load distribution branch circuiting, lighting, convenience receptacle and 120 VAC/20A incoming main control/instrument power circuit shall be individually protected with thermal magnetic circuit breaker, as shown on the PLANS.

2. Each cabinet instrument and/or control device (controller, indicator, control device, power supply, **PLC** I/O, etc.), process signal instrument loop power supply, and individual 120VAC control logic branch circuiting (for example, refer to the Substation No. 1 control logic circuitry as shown on the PLANS) shall be individually protected with a thermal magnetic circuit breaker, as shown on the PLANS.

3. Circuit breakers shall be U.L and CSA Listed, and shall be DIN-rail mounted, complete with visible trip indicator, as manufactured by **Allen-Bradley Series 1492-SP**. Size each circuit breaker to provide proper protection for instrument and/or control device served by the respective circuit breaker. Tag each circuit breaker similar to the terminal blocks, as defined under **Subsection 2.05 F.** of this Section of the Specifications.

B. 24 Volts D.C. Overcurrent Protection:

1. Each cabinet instrument and/or control device (controller, indicator, control device, power supply, etc.), process signal instrument loop power supply, and 24VDC instrument loop shall be individually protected with a thermal magnetic circuit breaker, as shown on the PLANS.

2. Circuit breakers shall be U.L and CSA Listed, and shall be DIN-rail mounted, complete with visible trip indicator, as manufactured by **Allen-Bradley Series 1492-GH**. Size each circuit breaker to provide proper protection for instrument and/or control device served by the respective circuit breaker. Tag each circuit

breaker similar to the terminal blocks, as defined under **Subsection 2.05 F.** of this Section of the Specifications

C. Instrument Control Cabinet General Interior Lighting:

Furnish interior lighting fixture where shown on the PLANS. Each lighting fixture shall be shall be LED lighting fixture, suitable for 120 volts AC operation. Each fixture shall be 2-feet long utilizing cool white color LED lamps. Each lighting fixture furnished shall also be furnished with an integral door activated switch wired to switch the light based upon the cabinet section door position.

D. Instrument Control Cabinet convenience receptacle:

Provide 120 VAC, 20A rated, specification grade grounded duplex receptacles. Refer to the PLANS for quantity required and additional requirements. Install receptacle inside control panel in NEMA-1 enclosure.

E. Instrument Control Cabinet UPS Receptacle:

Provide 120 VAC, 30A rated, specification grade grounded simplex twist-lock receptacle. Receptacle configuration shall be L5-30R, coordinate final configuration with the UPS requirements. Receptacle shall be Hubbell HBL2610 or approved equal. Refer to the PLANS for quantity required and additional requirements. Install receptacle inside control panel in NEMA-1 enclosure.

2.04 INSTRUMENT AND CONTROL CABINETS CONTROL DEVICES

A. Control Relays: Control relays shall be provided as required by the schematic diagrams. Refer to the PLANS. Mount control relays on the backpanels (device panels/subpanels) located inside the cabinets. As also shown on the wiring schematics shown in the PLANS, multiple types of control relays are required for this project. Refer to the PLANS. All control relays shall be Type I relays unless specifically noted otherwise on the PLANS or as specified hereinafter. The minimum requirements for the different types of relays are as described below:

1. Type I Relays: Relays shall be 600 volts Heavy-Duty industrial type with 120V coils. Minimum contact rating shall be 10A, continuous, at 120 volts AC. One additional normally open (N.O.) and one additional normally closed (N.C.) contact, in addition to those shown on the schematic diagram, shall be provided for each relay. Relays shall be furnished with visual mechanical latch-unlatch indicators. Additionally, coil of each relay shall be furnished with Relay Manufacturer's Transient Voltage Suppression Module. Relays shall be Allen Bradley Bulletin 700-P, or approved equal. So called "International" and IEC rated relays will not be accepted. All relays shall be standard NEMA size.

2. Type II Control Relays: <u>Relays shall be used only where specifically noted on the PLANS.</u> Relays shall be 300 volts "Ice-Cube" type with 24-volt DC (nominal voltage) coils. Minimum contact rating shall be 10A at 120 volts AC. Relays shall be configured with four (4) Form-C contacts (4PDT). Relay shall be equipped with LED indicator light and push-to-test button. Furnish relay complete with socket and retaining clip. Relay

socket shall be din rail mountable. Relays shall be "Allen-Bradley", catalog number 700-HF34Z24-3-4 complete with relay socket base catalog number 700-HN139 and relay retaining clip catalog number 700-HN140, or approved equal.

B. **Timing Relays**: Solid state, multi-time, and multi-function type relay. Both timing ranges and timing modes shall be field selectable. Each relay shall be capable of the following timing modes: On Delay, Off Delay, One Shot, Repeat Cycle, and Interval. Minimum relay contact rating shall be 10 amps, continuous, at 120 VAC. Coils shall be 120 VAC. Timing relays shall be **Square D Class 9050 model No. JCK70 complete with Type NR61 Socket, or approved equal**. One additional normally open spare contact and one additional normally closed spare contact shall be provided for each relay, in addition to those contacts shown on the schematic diagrams. Mount control relays on the backpanels (device panels/subpanels) located inside the cabinets.

C. **Elapsed Time Meters**: Non-Resettable type, cyclometric types reading at least to 9999.9 hours and at least to nearest one-tenth of an hour. **Eagle Signal/Danaher Controls series HK410**.

D. Pushbuttons, Selector Switches and Pilot Lights:

1. Indicating lights shall be NEMA Style, full size 30-millimeter (30mm), Transformer Type Light Emitted Diode (LED), NEMA 4/13 oil tight and watertight, full size, push to test type, rated at 120VAC, with legend plate marked as shown on the PLANS. Lens color shall be as shown on the PLANS. Refer to PLANS control schematics and details for the exact color requirements. Pilot lights shall be as manufactured by Allen-Bradley Bulletin 800T NEMA Type 4/13, oil tight and water tight. Miniature size pilot lights will not be accepted.

2. Pushbuttons and Selector Switches shall be Heavy duty NEMA 4/13, , oil tight/ water tight, NEMA Style full size 30-millimeter (30mm), pushbuttons and selector switches as required by the PLANS. The number of contact blocks shall be as required by the PLANS. The selector switches and pushbutton contacts shall be rated 10-amperes minimum at 120 volts AC. The selector switches shall be furnished with Black Knob Lever Operators. The color of the pushbutton operator shall be as shown on the PLANS, Black otherwise. Selector switches and pushbutton operators and contact blocks shall be Allen Bradley Bulletin 800T. Miniature size stations will not be accepted.

3. Mushroom Head Push Buttons: NEMA style, heavy duty, NEMA 4/13 watertight/oiltight mushroom head pushbutton with the number of contact blocks required by the schematic diagrams. Mushroom head pushbutton contacts shall be rated 10 amps at 120VAC. The contact blocks shall be provided with fingersafe guards (guards on contacts). The mushroom head pushbuttons shall be the two-position "Push-Pull" type with RED mushroom head button. The mushroom head pushbuttons shall be as manufactured by Allen-Bradley Bulletin 800T. Miniature size stations will not be accepted. Each button shall be provided with a hinged polycarbonate corrosion resistant locking cover. Cover shall be capable of closing without actuating the push button. Cover shall be C3 Controls Model LOAFC, or approved equal.

4. Legend Plates for Control Stations: Provide legend plates for each control station, and each pilot device installed in a control station per details shown on the drawings. Additionally, the legend plates shall be the Manufacturer's standard with lettering

indicated on the Plans. Legend plates shall be of the same manufacture as the respective pushbuttons, selector switches and pilot lights.

E. Flashing Light Beacons or Rotating Beacons: Flashing Light Beacons or Rotating Beacons shall be weatherproof, U. L. Listed. The beacon shall be furnished with an integral flashing unit rated for use with an LED lamp, a red polycarbonate lens, and be furnished complete with the LED lamp. The unit shall be rated for an operating voltage of 120VAC. Beacons shall be as manufactured by Edwards Signaling and Security Systems (General Electric), AdaptaBeacon series, model number 51XBRFR120A, or approved equal. The wiring for the horn of the unit shall be disconnected to disallow operation of the horn.

1. Accessories:

a. Provide wall mount bracket, Catalog No. WBR for each beacon.

b. Provide protective lens guard, Catalog No. 92-GRD for each beacon.

2.05 INSTRUMENT AND CONTROL WIRING

A. **General Wiring**: All control wiring shall be extra flexible 41-strand**, #14 AWG**, copper conductor, 600v insulation, **SIS wire** manufactured by **General Cable Company, The Okonite Company,** or approved equal. Color coding shall be as follows:

FUNCTION	COLOR CODE
120Vac control/status signal wiring. This does not apply to control/status signal wiring that are scheduled for interface with Programmable Logic Controller **(PLC)** and Alarm wiring	**Red**
120Vac control wiring to relay coils (L1 & L2 terminals or H&N terminals) that are not generated from a **PLC** Discrete Output point (**DO)**	**Gray**
120Vac power supply wiring to instrumentation and control devices that are not generated from a **PLC** Discrete Output point (**DO)**	**Gray**
Alarm wiring	**Yellow**
Wiring to instrument control cabinet interior lights/receptacle/exhaust-fans	**Red = Hot (phase-A)** **Black = Hot (phase-B)** **Blue = Hot (phase-C)** **White = Neutral**

FUNCTION	COLOR CODE
Control/status signal wiring to Programmable Logic Controller **(PLC)** -Discrete Input Modules (as shown on the PLANS)	**Violet**
Control/status signal wiring **from** Programmable Logic Controllers **(PLC's)** –Discrete Output Modules (**DO**'s as shown on the PLANS)	**Pink**
Ground Wires	**Green**
24Vdc instrument loop power wiring	**Blue = Positive (+)** **Brown = Negative (-)**

B. 4-20 Milliamp Signal wiring: Twisted pair, #16 AWG stranded copper conductors with PVC insulation over each conductor, a tinned copper drain wire, an overall aluminum-mylar shield and an outer PVC jacket. **Samuel Moore and Company, Dekoron Division, Cat. No. 1852** or equal. ***Color*** of the twisted pair shielded cable jacket shall be **GRAY**. The ***color*** of the positive (+) and negative (-) conductors within the each cable shall be **BLACK** and **WHITE** respectively.

C. Resistance Temperature Detector "RTD" Signal wiring: Twisted triad, #16 AWG stranded copper conductors with PVC insulation over each conductor, a tinned copper drain wire, an overall aluminum-mylar shield and an outer PVC jacket. **Samuel Moore and Company, Dekoron Division, Cat. No. 1862** or equal. ***Color*** of the twisted pair shielded cable jacket shall be **BLACK**. The ***color*** of the sense (+), negative (-), and common (-) conductors within the each cable shall be **BLACK**, **WHITE,** and **RED** respectively

D. ModBus Digital Data Communication System Wiring:

All ModBus Digital Data Communication System Wiring shall be twisted pair, #16 AWG stranded copper conductors with 600 volt PVC insulation over each conductor, a tinned copper drain wire, an overall aluminum myler shield and an outer PVC jacket. Instrument wiring cables shall be manufactured by **"Samuel Moore and Company, DeKoron Division, Cat. No. 1852"**. ***Color*** of the twisted pair shielded cable jacket shall be **ORANGE**. The ***color*** of the *SEND* and *RECEIVE* conductors within the each cable shall be **RED** and **BLACK** respectively

E. Ethernet Data Communication Cable: Refer to Section 17600 Distributed Control System.

F. Terminal Blocks and Routing/Termination of Wiring:

1. Terminate all incoming wiring and inter-cabinet wiring to terminal blocks, terminal blocks shall be NEMA rated Terminal Blocks, 600 volts with continuous current rating of 55-amperes. Terminal blocks shall be mounted on a Heavy Duty DIN Rail. Each terminal block shall be furnished with multi-character marking surface, complete with detachable multi-character marking surface (holder) extending the full width of the each terminal block. Terminal blocks shall be manufactured by **Allen-Bradley catalog No.**

1492-HM3 (37 terminals per foot), Phoenix Contact, or approved equal, with **1492-SMN81 Marking System** for multi-character marking surface, complete with detachable multi-character marking surface (holder) extending the full width of the terminal block. Provide separate terminal blocks for power wiring, from control/discrete signal wiring, and from analog/instrument wiring. Tag each terminal. Each terminal shall have the same tag as the tag of the wire connected to the respective terminal. All tags must be typed and neatly attached to the marking surface (utilize adhesive tags). Also, identify each strip/string of terminal blocks with **3-ply phenolic "Black-White-Black" identification nameplate**. Utilize plated insulated copper terminal-to terminal jumpers for making connections between adjacent terminal blocks and/or between terminal blocks located on the same terminal strip. Jumpers shall be as manufactured by Allen-Bradley, catalog no. 1492-SJ8-10, Phoenix Contact, or approved equal. Use of wire as jumper between terminal blocks will not be accepted. The ***color*** of **each** Terminal Blocks shall be based on function and type of the wiring terminated to the block. The color coding of the terminal blocks shall be as follows:

FUNCTION	COLOR CODE
TERMINAL BLOCKS for 120Vac control/status/alarm signal wiring. This APPLIES TO ALL control/status signal wiring and including 120Vac control/status signal interface wiring with Programmable Logic Controller **(PLC)** and Alarm wiring	**RED**
TERMINAL BLOCKS for 120Vac control wiring to relay coils (L1 & L2 terminals or H&N terminals) INCLUDING THOSE that are generated from a **PLC** Discrete Output point (**DO)**	**RED**
TERMINAL BLOCKS for 120Vac power supply wiring to instrumentation and control devices and communication instruments	**BLACK**
Wiring to instrument control cabinet interior lights/receptacle/exhaust-fans	**BLACK**
Ground Wiring terminal blocks, including shield wiring terminal blocks within the 4-20mAdc signal wiring terminal strip	**GREEN**
Terminal Blocks for 4-20mAdc process signal wiring POSITIVE (+) and NEGATIVE (-) terminals	**WHITE**

2. Route all wiring from an instrument through the terminal block to the other instrument rather than directly from one instrument to the other. This also applies to wiring between pushbutton selector switches, relays, relay contacts, and pilot lights. Also, refer to the PLANS.

3. Route power supply wiring or wiring common to more than one device or instrument individually from the terminal strips to each device. Do not loop wiring between devices.

4. Group all wiring where possible and neatly lace with waxed twine or wrap with a clear polyethylene flexible spiral wrapping by **Electrovert Spiraband** or approved equal. Wiring routed against back panel of the control panel may be installed in plastic wireways by **Panduit** or approved equal. However, where wiring is routed on inside face of control panel access door and where not possible to route in plastic wireway installed on the back panel, waxed twin or spiral wrapping must be used.

5. Route wiring to equipment on doors (if applicable) so that the doors can be opened to the fullest extent of travel without stressing the wiring.

6. Terminate shield wire of each shielded cable to a terminal point (block) on the terminal strip (i.e., treat as current carrying conductor). Do not terminate more than one shield wire to a single terminal block (point). i.e., each twisted pair shielded cable should have three termination points independent/isolated from termination points of neighboring cables. Extend #14 AWG insulated green ground wire from each shielded cable shield termination terminal point to the isolated main ground bar of the cabinet (shield/drain wire ground).

7. Terminal point on a device, relay, instrument, etc. will not be considered the same as terminal located on a terminal block. Terminal blocks, terminal symbols, etc. shown on the drawings are in reference to terminal blocks, terminals, etc. independent of any terminal strip and/or termination point furnished with/on the device, relay, instrument, etc. by the device, relay, instrument, etc. Manufacturer. Additionally, spare contacts of each device (i.e. control relays, timing relays, selector switches, etc.) must also be pre-wired (in same fashion) to terminal blocks (although they shall serve as spare points). Wiring and termination points of spare points of all equipment must be treated the same as any other active point and must follow the same format described under wiring/terminal block tagging scheme/strategy/method.

8. Wiring and termination points of spare points (spare wires, if any) shall be tagged, terminated to terminal blocks/strips (i.e., not left coiled inside the Cabinet) and shall be treated the same as any other active point and must follow the same format described under wiring/terminal block tagging scheme/ strategy/method. The spare terminal blocks/strip shall be identified as ***future use - spare terminal block strip.***

2.06 INSTRUMENT AND CONTROL CABINETS INSTRUMENTATION EQUIPMENT

A. Single Input, Single Output Instrument Loop Current Isolators (I/I Converters):

1. Furnish single input, single output instrument loop isolators (I/I Converters) where shown on the PLANS.

2. The loop current isolators shall be designed for one 4-20mA input and one 4-20 mA isolated output signal and equipped with a built-in load trimmer.

3. The loop isolator shall be capable of driving a 4-20mA signal into a maximum load of 1000 Ohms on the output channel.

4. The loop current isolator shall be powered from an external 24 VDC supply as also shown on the PLANS.

5. The output loop current accuracy shall be +/- 0.1% of full span. The loop isolator shall be equipped with RFI/EMI protection such that less than +/- 0.1 % of span error is incurred when tested against a reference signal of 30 volts per meter over the frequency range of 20 to 1000 MHz, inclusive.

6. Each loop isolator shall be equipped with the field selectable transmitter excitation option which allows the isolator to supply 24VDC power to a 2-wire instrument connected to the isolator input. For those instruments which do not source DC power to the isolator input loop, wire the isolator so that it supplies 24VDC power to the input loop. For those instruments which source DC power to the isolator input loop, wire the isolator so that it does not supply DC power to the input loop.

7. The loop isolator shall be of the high-density type with corrosion resistant metal housing. The isolators shall be mounted on a rail (DIN-rail mounting) in the control panel where shown on the PLANS. Each loop isolator shall be tagged by loop number and loop process identification, as also shown on the PLANS.

8. The loop current isolators shall be as manufactured by MOORE Industries Model ECT-DIN with TX and RF options, or approved equal.

B. Single Input, Dual Output Instrument Loop Current Isolators (I/I Converters)

1. Furnish single input, dual output instrument loop isolators (I/I Converters) where shown on the PLANS.

2. The loop current isolators shall be designed for one 4-20mA input and two 4-20 mA isolated output signal and equipped with built-in load trimmers.

3. The loop isolator shall be capable of driving a 4-20mA signal into a maximum load of 1000 Ohms on each output channel.

4. The loop current isolator shall be powered from an external 24 VDC supply as also shown on the PLANS.

5. The output loop current accuracy shall be +/- 0.1% of full span. The loop isolator shall be equipped with RFI/EMI protection such that less than +/- 0.1 % of span error is incurred when tested against a reference signal of 30 volts per meter over the frequency range of 20 to 1000 MHz, inclusive.

6. Each loop isolator shall be equipped with the field selectable transmitter excitation option which allows the isolator to supply 24VDC power to a 2-wire instrument connected to the isolator input. For those instruments which do not source DC power to the isolator input loop, wire the isolator so that it supplies 24VDC power to the input loop. For those instruments which source DC power to the isolator input loop, wire the isolator so that it does not supply DC power to the input loop.

7. The loop isolator shall be of the high-density type with corrosion resistant metal housing. The isolators shall be mounted on a rail (DIN-rail mounting) in the control panel where shown on the PLANS. Each loop isolator shall be tagged by loop number and loop process identification, as also shown on the PLANS.

8. The loop current isolators shall be as manufactured by MOORE Industries Model ECT-DIN with TX and RF options, or approved equal.

2.07 24 VDC INSTRUMENT LOOP POWER SUPPLIES

A. Provide power supplies installed and wired as shown on the PLANS in accordance with the following specifications.

B. Instrument Control Panels/Cabinets Dual Input Single Output 24 VDC Power Supplies:

Provide dual input single output 24 VDC Power Supplies were required by the PLANS. 24 VDC Dual Input Single Output 24 VDC Power Supplies shall be provided as dual Redundant primary-backup (secondary) arrangement 24 VDC switching type power supplies connected in parallel via current steering diodes with automatic switchover from the primary to the backup (secondary) power supply unit. The secondary power supply shall recover 24 VDC power to the system immediately and shall sound and alarm when a switchover has taken place (i.e., when the primary power supply unit has failed). The alarm contacts shall be rated 5-amps at 120 volts AC. Connect the alarm contacts to the Discrete Input Point on the Programmable Logic Controller (**PLC**) inside the Main Control Panel (LPU) as also shown on the PLANS. These power supplies shall operate from 120 VAC input power and shall provide direct current output current of 15 amperes (each unit) at 24 VDC at 40 degrees C, and shall be adjustable from 24 to 28 VDC by screw driver operated adjustment. Input power regulation shall be 0.2% from 105 to 130 VAC. Output load regulation shall be 0.2% maximum from zero to full load. Ripple shall not exceed 0.5% at full load. The power supplies shall have integral output current limiting and over-voltage protection. The power supplies shall have fully enclosing cases. The power supply shall be manufactured by **Acopian (Redundant Power Supply Unit)**, or approved equal.

Each power supply unit's draw-out assembly shall be furnished by the Power Supply Manufacturer. Additionally, each power supply unit shall be furnished with the following additional features by the Manufacturer of the Power Supply.

1. Draw-out handles mounted on the face of the power supply unit.

2. Voltage level analog indicator, one per source (primary and redundant).

3. Current level analog indicator, one per source (primary and redundant).

C. Instrument Control Panels/Cabinets Single Input Single Output 24 VDC Power Supplies:

Provide single input single output 24 VDC Power Supplies were required by the PLANS. Each 24 VDC Single Input Single Output 24 VDC Power Supply shall be provided with alarm contacts rated 5-amps at 120 volts AC. Connect the alarm contacts to the Discrete Input Point on the Programmable Logic Controller (**PLC**) inside the Main Control Panel (LPU) as also shown on the PLANS. Each power supply shall operate from 120 VAC input

power and shall provide direct current output current of 5 amperes at 24 VDC at 40 degrees C, and shall be adjustable from 23.5 to 24.5 VDC by screw driver operated adjustment. Input power regulation shall be 0.2% from 105 to 130 VAC. Output load regulation shall be 0.2% maximum from zero to full load. Ripple shall not exceed 250 millivolts at full load. Each power supply shall have integral output current limiting and over-voltage protection. Each power supply shall have fully enclosing cases. Each power supply shall be manufactured by **Acopian model Gold Box Single Ouput Linear Regulated Series A**, or approved equal.

2.08 INSTRUMENT CONTROL PANELS/CABINETS UPS:

A. Where required by the PLANS, furnish and install the quantity of Uninterruptible Power Supply (UPS) units in each of the instrument/control/communication cabinets as shown on the PLANS. Each UPS shall be as follows:

1. The UPS shall have the apparent power rating as shown on the PLANS at minimum.

2. Each UPS shall operate from 120 VAC input power and shall provide 120 VAC output power. The UPS shall have a capacity to deliver the continuous full load AC output current shown on the PLANS at 120 VAC for fifteen (15) consecutive minutes at minimum, after the input power is removed. The output wave-form shall be 60Hz sinusoidal with 5% maximum harmonic distortion. The UPS shall be filtered with 0.3% IEEE surge let-through and zero clamping response time, complying with UL 1449 requirements. The output shall have over-current protection with latched shutdown.

3. The UPS shall consist of a field configurable bypass mode for automatic or manual bypass to the AC input source

4. The UPS shall consist of automatic self test, executed on start up and at regular intervals (minimum of once per 14 days), and fault detection LED annunciating self test failure. Upon inverter module failure, the UPS shall automatically direct connect the connected load to the input power source and bypass the inverter module.

5. The UPS shall consist of automatic voltage regulation to maintain its sine wave output in accordance to these specifications. The settings for the UPS AC input source voltage high and low values to initiate transfer to battery power shall be field adjustable.

6. The UPS shall have the following front panel indications (LED type) and alphanumeric display:

   a. UPS On Status

   b. Fault

   c. On Battery

   d. Bypass

   e. Battery Replacement Needed

7. The UPS shall have the following audible alarms:

    a. UPS failure

    b. Battery failure

    c. Power loss to the UPS

8. The UPS shall have the following front panel mounted push buttons:

    a. Energizing UPS

    b. De-energizing UPS

    c. Manual UPS Self test initiation

9. The batteries shall be maintenance-free, fumeless, sealed, leak proof batteries that are accessible for replacement by the OWNER. The batteries shall be rated for use in Computer Rooms (by NFPA and all other Safety Codes). Batteries shall have maximum of five (5) hours to charge to 95 percent capacity. Provide battery extension cabinet where required to obtain a minimum duration runtime of fifteen (15) minutes for the connected load in the event of a power loss and where shown on the PLANS.

10. The UPS shall be provided with a manufacturer's standard external maintenance bypass switch. The external maintenance bypass switch shall be sized such to carry the full load current of the UPS inclusive of inrush current, at minimum. Also refer to the requirements shown on the PLANS. The maintenance bypass switch shall be installed in such a manner that the selector switch is accessible from the front of the control cabinet. Provide any additional accessories necessary to facilitate the installation of the maintenance bypass switch.

11. The UPS and the battery backup units shall be installed in a NEMA-12 enclosures

12. The UPS shall be able to operate from 0 to 40 degrees C.

13. Accessories:

    a. The UPS shall consist of a relay I/O module which provides 24VDC, 1A rated relay output contacts. At minimum, the card shall consist of a dry contact indicating UPS fault, and a dry contact indicating requirement for Battery Replacement. Wire the UPS fault alarm, the battery replacement alarm, and the UPS in bypass status in series to a 24VDC rated Type II control relay as specified in section 17200. An alarm contact from the 24VDC UPS fail relay shall be wired as a discrete input into the programmable logic controller to indicate a UPS common trouble/fail alarm. Also refer to PLANS for wiring to the UPS relay I/O module.

    b. The UPS shall be provided with all necessary interconnecting cables, connectors, Windows compatible configuration software (if necessary), for a complete and functional installation.

c. Provide all 19 inch rack mounting brackets, miscellanous mounting hardware to facilitate the mounting shown on the PLANS. Provide for the mounting configuration as shown on the PLANS. Mount UPS within the control cabinet, without obstructing access to components within cabinet. Install UPS in accordance to manufacturers requirements and recommendations, including proper UPS power termination, ventilation, and cooling.

14. The UPS shall have a two (2) year manufacturer's warranty at minimum after the final completion of the project

15. The UPS shall be as manufactured by Eaton Model 9PX Series UPS with external maintenance bypass switch Eaton HotSwap MBP Model EHBPL****R-PDU1U (where **** is based on UPS rating shown on the PLANS), and Relay Interface Card Eaton Model No. Relay-MS , or approved equal.

2.09 PROGRAMMABLE LOGIC CONTROLLERS "PLCS" AND ASSOCIATED EQUIPMENT

A. Refer to Specifications Section 17600 of this Division of the Specifications.

2.10 FIBER OPTIC CABLES, CHORDS, MODEMS AND ASSOCIATED EQUIPMENT

A. Refer to Specifications Section 17600 of this Division of the Specifications.

2.11 INSTRUMENT AND CONTROL DEVICES IDENTIFICATION

A. All devices on the face, on the back, and inside the instrument control cabinets/panels and shall be permanently identified. The device designations shall agree with those shown on the PLANS and per the equipment tagging requirements of Austin Water Utility. Each device shall be provided with permanent type identifying nameplate. Nameplates, unless otherwise specified, shall be constructed of **3-ply "Black-White-Black"** laminated phenolic material having engraved letters approximately 1/4 inch high minimum (and/or of size shown on the drawings) extending through the black face into the white layer. Nameplates located on the panels/cabinets face shall be secured with two Stainless Steel screws.

B. All field mounted control and instrument devices shall permanently identified. The device designations shall agree with those shown on the PLANS and per the equipment tagging requirements of Austin Water Utility. Each device shall be provided with permanent type identifying nameplate. Nameplates, unless otherwise specified, shall be shaped as a circle and shall be constructed of **3-ply "Black-White-Black"** laminated phenolic material having engraved letters approximately 1/4 inch high extending through the black face into the white layer. Securely hang nameplates from each instrument/control device by a flexible stainless steel snap-on type hanger/key-chain cord (neatly drill a hole through the top of the identification nameplate for this purpose).

PART 3 - EXECUTION

3.01 SHIPMENT AND STORAGE

A. Cabinets shall be prepared for shipment in weatherproof and crush-proof containers.

B. Handling of cabinets shall be accomplished with extreme care, especially after removal from shipping containers.

C. Storage: *Refer to Specification Section 17100, paragraph 2.04*.

3.02 INSTALLATION

A. Cabinets shall be installed in the locations shown on the PLANS.

B. All wiring shall be connected as shown on PLANS and all systems shall be thoroughly checked out.

C. Install all equipment in accordance with the PLANS and instructions furnished by the manufacturer.

D. Inspect each new instrument, control component, etc., before installation. Replace deficient items.

E. Special and additional installation requirements associated with fiber optic communication system:

1. The fiber cables entering each cabinet shall be coiled, allowing at least 8-feet of additional cable. The coiled fiber shall be positioned vertically. The fiber bend radius upon entry and coiling must not be less than the minimum required for the cable.

2. The fiber optic cable shall be enclosed in a plastic, flex material. This flex material shall surround the cable for all routing of the cable.

3. One side of the Cabinet frame shall be surrounded by plastic wireways (wire arrangement and jumper management devices) for the patch chords to be routed through. Similarly, the area between the patch panel and the network switch shall consist of a wire management section for the patch chords to be routed through. All these wire management devices shall have a cover plate so as to conceal the patch chords routed within them. The wire management devices shall be able to support at least 72 patch chords. The plastic wireway product shall be as specified under Subsection-2.0 PRODUCT, of this Section of the Specifications. However, the Color of the Plastic Raceway shall be BLACK.

3.03 INSTALLATION REPORT

A. After installation, the manufacturer's representatives shall inspect the installation and prepare a report or reports to include the following:

1. A list of all deficiencies found.

2. Recommend corrective action for all facilities.

3. Certification that the item or system is properly installed, except as noted.

3.04 FIELD CALIBRATION AND TESTING

A. Calibrate instruments and prepare calibration reports. All calibration shall be performed by factory-trained technical personnel. Calibration shall be witnessed by Owner's Personnel and Engineer.

B. The complete system shall be tested by experienced factory-trained technical personnel. All system tests shall be witnessed by Owner's Personnel and Engineer.

C. Perform the following tests using simulated inputs:

1. Check the overall system and each subsystem to see that they function as specified based on simulated inputs at each sensor and at each set of field contacts monitored. This check to include the testing of all automatic functions, sounding of alarms, shutdowns, etc.

2. Check the overall accuracy of each new and modified instrument loop to ensure that it is within acceptable tolerance.

D. If defects are found under simulated conditions, make corrections and retest.

E. After start-up, test the complete system under actual conditions to determine that all specified functions can be performed.

F. After completion of testing, submit a System Test Report. This report to include:

1. Certification that the system is operating correctly and within tolerances.

2. Listing of calculated tolerances for each new and modified instrument loop.

3.05 ON-SITE OPERATIONS AND MAINTENANCE TRAINING

A. Start-up Training: Provide required instruction to the Owner's personnel during start-up period.

B. Special Training School: Provide services of a factory-trained instructor or instructors for a period of not less than **FIVE (5) WORKING DAYS** for the purpose of instructing the Owner's personnel in the correct operating and maintenance procedures for all the instrument and hard-wired control system components and the entire Instrumentation and Control System, and Communications System including the various instrument and control system cabinets/panels installed in this project. This is in addition to the training requirements defined in *Section 17100 of the Contract Specifications*. The date of this school shall be scheduled with the Owner, but will be after the entire instrument and control systems is in operation. Also, refer to the additional training requirements defined in *Section 17100 of the Contract Specifications*.

3.06 MEASUREMENT AND PAYMENT

A. No separate measurement or payment for work performed under this Section. All costs are included in the Base Bid.

END OF SECTION

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SECTION 17380

FIELD INSTRUMENTATION AND SENSING DEVICES

PART 1 - GENERAL

1.01 SUMMARY

A. The work performed under this Section consists of furnishing, installing, calibrating and placing into satisfactory service the following field mounted devices/elements as shown on the PLANS:

1. Intelligent Differential Pressure Measuring Indicating Transmitters
2. Intelligent Temperature Measuring Indicating Transmitters
3. Intelligent Humidity Measuring Indicating Transmitters
4. Air Duct Mounted Pressure Indicating Transmitters
5. Hydrogen Gas Analyzer and Indicating Transmitters
6. Tubing, Hand Valves and Fittings

B. The subsequent document entitled "Appendix A – Instrument List" is hereto made part of this section and includes a listing of the proposed instruments.

1. The minimum and maximum range in the Instrument List provides the required calibrated span of each instrument.
2. Where the instrument functions as a switch, the minimum/maximum value indicates the low/high switch setting. Where the value is noted as "N/A", the low or high setting is not applicable for the instrument.
3. The Instrument List is not inclusive of all instruments required by this contract. Refer to Part 1 of this section for quantities of spare parts and instruments in addition to those listed in the Instrument List. Refer to the PLANS and other specification sections for additional instruments required by these contract documents.
4. Where a PLAN sheet number is shown in the list, and a "/" is listed, the number shown prior the "/" refer to a specific detail number on that sheet.
5. The list includes PLAN drawing numbers applicable to the specific instrument installation and wiring. This list of drawing numbers is not complete. Refer to the PLANS for additional instances and requirements for these instruments.
6. Where items in the list are left blank and/or not entered, the CONTRACTOR shall note these items on the data submittals and request input from the Process Mechanical ENGINEER for clarification during submittal review.

C. Instrument Type Code:

1. An Instrument Type Code identifies each instrument and consists of alphabetical character(s) followed by three numeral characters.

a. Example Instrument Type Code: “A123”.

2. The Type Code listed in the Instrument List serves as a means to reference each instrument in the Instrument List to the specifications.

1.02 RELATED REQUIREMENTS

A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.

B. It is the CONTRACTOR’s responsibility for scheduling and coordinating the Work of subcontractors, suppliers, and other individuals or entities performing or furnishing any of CONTRACTOR’s Work.

1.03 SUBMITTALS

A. Submit the following in accordance with the Section 01300 and 01730 of the Specifications and in accordance to Section 17100 of the Specifications:

1. Shop Drawings and product data.

2. Submit wiring schematics for all equipment.

3. Submit certifications of training associated with proper installation the fiberglass reinforced vinyl ester support channel system.

4. Test Reports: Completed and certified factory and field calibration data sheets for instruments and devices that require set-up and calibration.

   a. Include factory calibration for each instrument with stated accuracy.

5. Operation and maintenance manuals.

   a. Include all completed and certified test reports in manuals.

      1) Refer to specifications herein for transmitter ambient and process fluid temperature ranges to be used for basis of accuracy analysis.

6. Submit detailed listing of training class curriculum including, as a minimum, the following at least four (4) months prior to class:

   a. Specific topics for each instrument, including but not limited to, general trouble-shooting, calibration, wiring, and general set-up/configuration.

   b. Anticipated duration of class for each instrument type.

   c. Names of instructor(s) for each specific instrument.

   d. Refer to instrument by Instrument Type Code as listed in this specification section where applicable.

1.04 QUALITY ASSURANCE

A. Standardization: All equipment of the same Instrument Type Code to be the product of a single manufacturer.

B. Examine the complete set of Contact Documents and verify that the instruments are compatible with the installed conditions including:

1. Process conditions: Fluids, pressures, temperatures, flows, materials, etc.

2. Physical conditions:

a. Installation and mounting requirements.

b. Location within the process.

c. Accessories: Verify that all required accessories are provided and are compatible with the process conditions and physical installation.

C. Notify the ENGINEER if any installation condition does not meet the instrument manufacturer's recommendations or specifications.

D. Contractor shall be trained and certified by the Fiberglass reinforced vinyl ester support channel manufacturer in the proper installation of the fiberglass reinforced vinyl ester support channel system where such products are specified for this Work.

E. Material Compatibility:

1. Material selections of instrument components noted in this section provide a basis for the minimum material compatibility requirements.

2. Instrument component material selections shall be subject to additional restrictions and compliance with recommendations of instrument manufacturers for the intended service.

3. Provide instrument component materials in compliance with specific process fluid temperature, pressure, chemical compatibility, and other process fluid parameters.

1.05 TOOLS AND SPARE PARTS

A. Furnish the following spare Field Instrumentation and Sensing Devices in conformance with the Specifications:

1. One set of complete Type P203 Intelligent Differential Pressure Measuring Indicating Transmitter, furnished complete with accessories specified.

2. One set of complete Type T103 Intelligent Temperature Measuring Indicating Transmitter, furnished complete with accessories specified.

3. One set of complete Type T118 Intelligent Temperature Measuring Indicating Transmitter, furnished complete with accessories specified.

4. One set of complete Type H105 Intelligent Humidity Measuring Indicating Transmitter, furnished complete with accessories specified.

5. One set of complete Type A107 Hydrogen Gas Analyzer and Indicating Transmitter, furnished complete with accessories specified.

6. Five sets of Instrument Tubing Hand Valves.

7. Five sets of Instrument Tubing Elbow Fittings and Tee Fittings.

B. Cable lengths and capillary lengths of spare instruments/equipment shall match that of installed respective type of instrument/equipment. Where lengths of same type of installed instruments are not the same, respective spare instrument shall be provided with cable length and/or capillary tubing length matching longest cable and/or capillary tubing length of respective set of instruments installed. Provide all accessories, kits and mounting hardware as specified for each spare instrument.

C. Spare instrument shall be configured to match one of the installed instruments.

1. Where multiple instruments of the same type are installed:

a. Configuration of spare instrument shall be as directed by Engineer during construction.

b. Request input from Engineer during submittal process as to which configuration is desired for the spare instrument.

D. Furnish the following tools:

1. Three (3) handheld HART communicator configurators, each complete with 120 Vac charging station, test lead kit, rechargeable battery, USB cable, carrying case, hand strap, SD card, and software as manufactured by Yokogawa Model YHC5150X FieldMate Handheld Communicator, no equal.

1.06 ACCEPTABLE MANUFACTURERS

A. Each type of Instrument shall be manufactured by a single Instrument manufacturer and additional requirements as follows:

1. All pressure indicating transmitters shall be manufactured by a single Instrument manufacturer.

2. All temperature indicating transmitters shall be manufactured by a single Instrument manufacturer.

3. All level indicating transmitters shall be manufactured by a single Instrument manufacturer.

B. Refer to the individual instrument subsection in PART 2 - PRODUCTS, below.

PART 2 - PRODUCTS

2.01 INTELLIGENT DIFFERENTIAL PRESSURE MEASURING INDICATING TRANSMITTER

A. P200 Series General Requirements:

1. The Differential Pressure Indicator/Transmitter shall have the following features:

a. Signal: Two-wire 4-20 mAdc (loop powered) and having an integral digital signal based on the HART communication protocol.

1) Alarm: Configure the unit fault/alarm at 21.75 mAdc output signal.

b. Measurement Stability Period: 10 years

c. Unit Warranty: 12 years

d. Ambient Temperature Range: –40 degrees Fahrenheit to +175 degrees Fahrenheit

e. DC Loop Supply Voltage Range: 12 to 42 VDC.

f. Signal Output Load Range: 200 to 1,450 ohms.

g. Measurement Range: Select the measurement range offered by the instrument manufacturer for the specified model series that offers the greatest available accuracy for the required span of measurement as listed in Appendix A – Instrument List.

h. Indicator Requirements:

1) Type: Digital LCD integral to transmitter

2) Calibration: Field configurable, as desired by the user

a) Span: As listed in Appendix A – Instrument List.

b) Measurement Unit: As listed in Appendix A – Instrument List.

i. Power: Loop powered (4-20mA at 24 VDC) with 1/2" NPT conduit connection.

j. Sensor Wetted Parts Material: Type 316L Stainless Steel.

k. Sensor traditional bottom works, process covers and process connectors: Type 316-Stainless Steel with supply vent screw in side of each process cover with traditional bottom works flange (not coplanar) configuration.

l. Sensor Fill Fluid: Silicone oil.

m. Process Connection: 1/2 inch NPT.

n. Transmitter Housing: Epoxy coated aluminum, explosion proof NEMA-4X.

o. Hardware: Type 316 Stainless Steel.

p. Local Operation: The Indicator/Transmitter shall be equipped with operators on the face of the unit adjacent to the local indicator for configuration and calibration functions. The face of the unit is the side of the unit that includes the local indicator.

2. Process Pipe Pressure Tap Valves: Refer to PLANS for valving on process piping pressure tap, in addition to any instrument valves specified in this section.

3. Output Signal Configuration Capabilities:

a. Differential Pressure Measurement Application: Convert the pressure differential to a 4-20 mAdc electrical output that is proportional and linear to the differential pressure.

b. Flow Measurement Application: Convert the pressure differential across the flow tube element to a 4-20 mAdc electrical output that is proportional and linear to the flow rate of the measured fluid.

4. Flow Measurement Applications: The pressure span shall be obtained from the flow element pressure characteristics associated with the listed flow span.

5. Mounting: Manufacturer's Type 316 Stainless Steel mounting bracket suitable for mounting transmitter assembly on 2-inch pipe stand, support channel, wall/panel or other surface as shown on PLANS. Provide stainless steel flange to mount vertical pipe stand to floor. Refer to the PLANS for additional requirements.

6. Instrument Tubing: Provide instrument tubing to process line connections at valve block process ports. Refer to tubing and fittings requirements in this Specification Section. Refer to PLANS for additional requirements.

7. The Intelligent Differential Pressure Measuring Indicators/Transmitters shall be as manufactured by Rosemount Series 3051S Ultra Class for Differential Pressure or Level Measurement Application and Series 3051S Ultra for Flow Class for Flow Measurement Application or greater accuracy (Intelligent D/P Transmitters) with specified accessories, or Engineer approved equal.

B. P203: Intelligent Differential Pressure Measuring Indicating Transmitter with Tubing and Instrument Valves for Differential Pressure and Level Measurement Application

1. General Requirements for P200 Series Intelligent Differential Pressure Measuring Indicating Transmitters apply to this type of instrument.

2. The Differential Pressure Indicator/Transmitter shall have the following features:

a. Accuracy: ±0.025% of span; for spans less than 10:1, ±[0.005 + 0.0035(URL / Span)]% of span; Ultra Class or greater accuracy.

1) The "URL" in the above accuracy statement is the Upper Range Limit of the instrument.

3. Instrument Valves: Provide factory furnished, 5-way Valve Block Manifold; constructed of 316 Stainless Steel wetted and non-wetted parts, to accept 1/2 inch NPT; with gaskets and 316 Stainless Steel bolts; Anderson Greenwood Model M24T-VIS4 with Model MB55S Type 316 Stainless Steel mounting bracket or Engineer approved equal. Refer to PLANS for additional valving on process piping pressure tap and flow element tap.

4. Mounting of Manifold and Transmitter: Mount manifold directly with specified manifold mounting bracket. Manifold shall be installed between Transmitter bottom works and bracket. Transmitter shall be supported by manifold.

5. Instrument Tubing: Provide instrument tubing to process line connections at instrument ports and as required to connect instrument valves to instrument, process connections, and as shown on the PLANS. Refer to tubing and fittings requirements in this Specification Section. Refer to PLANS for additional requirements.

2.02 AIR DUCT MOUNTED PRESSURE MEASURING INDICATING TRANSMITTER

A. P303: Air Duct Mounted Pressure Indicating Transmitter

1. General Requirements:

   a. Measurement Range: 0 to 1 inch water column.

   b. Accuracy: +/- 0.25% of full scale.

   c. Enclosure Rating: NEMA 4.

   d. Output Signal: 4-20 ma.

   e. Power Type: loop powered.

   f. Display Type: LCD.

   g. Control Conduit Connection: 1/2-inch NPT.

   h. Static Duct Pressure Probe Length: 8-inch.

2. Each Air Duct Mounted Pressure Indicating Transmitter shall be as manufactured by Setra Model 2671-001WD-11-AP-FD with specified accessories, or Engineer approved equal.

2.03 INTELLIGENT TEMPERATURE MEASURING INDICATORS/TRANSMITTERS

A. T100 Series General Requirements:

1. The Temperature Indicators/Transmitters shall be of the intelligent type and shall measure and convert the temperature from a temperature sensor element to a 4-20 mAdc electrical and digital output that is Linear with the actual temperature of fluid being measured.

2. The Temperature Indicator/Transmitters shall have the following features:

   a. Communication Signal: Two-wire 4-20 mAdc (loop powered) and HART digital output (software selectable) proportional and Linear with the actual measured temperature of the process variable.

   b. Temperature Span: 140 degrees F to 1200 degrees F.

   c. Accuracy: 0.02 percent of calibrated span of the 4-20mA analog output

   d. Stability: 0.25 percent of calibrated span or 0.5 degrees Fahrenheit, whichever is greater, for five years.

   e. Operating Temperature: –40 degrees Fahrenheit to +185 degrees Fahrenheit.

   f. DC Loop Supply Voltage: 12 to 42 VDC.

   g. Output Load: 0 to 1,250 Ω (Ohms).

   h. Conduit Connection: 1/2 inch NPT.

   i. Digital Accuracy: +/- 0.18 degrees Fahrenheit.

   j. Hardware: All bolts, process connections, and hardware shall be Type 316 Stainless Steel.

k. Housing:

1) Enclosure of the Indicator/Transmitter shall be Low-copper aluminum.

2) Rated for use in Class-I, Division 1, Groups C and D hazardous areas (as classified by NFPA 70 National Electrical Code).

l. Local Indication:

1) Local indicator (integral to Indicators/Transmitters) which is calibrated in "degrees F" and to the range of the transmitter (or to the range of the process variable range selected by the Owner).

2) The indicator shall be of the digital type with liquid crystal display (LCD), driven by the loop power (4-20mA at 24 VDC), and have an accuracy within 0.075 percent full scale.

m. Local Operators:

1) The Indicator/Transmitters shall be equipped with operators on the face of the unit for configuration and calibration functions.

2) External and/or internal source/devices (such as handled programmer and/or Portable Computer) shall not be required in order to configure, program, and calibrate the Indicators/Transmitters.

n. Mounting Hardware: Manufacturer's Type 316 Stainless Steel mounting bracket suitable for mounting transmitter on 2-inch pipe stand, support channel, wall/panel or other surface as shown on PLANS. Refer to the PLANS for additional requirements.

3. The Temperature Sensor Element for each Indicator/Transmitter shall have the following features:

a. General: 4-wire, single element, 100Ω (Ohms) Resistance Thermometer Detector (RTD), Platinum, in accordance with IEC 60751 Class A.

b. Enclosure: Enclosed in a Type 316 Stainless Steel sheath.

c. Sensor Lead Wire Termination: For application where sensor is not mounted integral to the transmitter, provide sensor with aluminum connection head and cover with 1/2 inch NPT conduit connection.

d. Sensor Assembly: Type 316 Stainless Steel spring-loaded style sensor assembly having 1/2 inch NPT.

e. Temperature Range: -328 to +932 degrees Fahrenheit.

f. Length: Provide length of element required to span entire length of thermowell and required sensor connections.

4. The Sensor Element Thermowell shall have the following features:

a. General: Each Sensor Element shall be provided with a Type 316 Stainless Steel Full Length thermowell (protecting tube).

b. Shank Style: Tapered shank geometry, with smaller diameter at terminal tip of thermowell.

c. Hardware: The thermal well assembly shall be furnished complete with external threads, explosion proof union, and required accessories/hardware for installation onto process mechanical piping, duct/chamber and/or raceways shown on PLANS. All mounting accessories/hardware shall be constructed of Type 316 Stainless Steel.

1) Exception: Union is not required when thermowell is mounted only to transmitter and not mounted to process mechanical piping, duct/chamber, raceways or other fixed element.

5. Each Intelligent Temperature Measuring Indicator/Transmitter along with the associated Temperature Sensing Element and System shall be as manufactured by Rosemount Series 644 Intelligent Temperature Transmitters with Series 214C Sensor Element, Series 114C Thermowell and specified manufacturer furnished accessories, or Engineer approved equal.

B. T103: Intelligent Temperature Measuring Indicators/Transmitters with Integral Temperature Element for Ambient Temperature Measurement

1. General Requirements for T100 Series Intelligent Temperature Measuring Indicators/Transmitters apply to this type of instrument.

2. The Temperature Indicator/Transmitters shall have the following features:

a. Mounting: Integral to sensor.

3. The Sensor Element Thermowell shall have the following features:

a. Length: 6 inches.

b. Sensor Assembly Connection: Mounted directly to Indicating Transmitter with required 316 Stainless Steel connector fittings.

C. T118: Intelligent Temperature Measuring Indicators/Transmitters with Remote Mounted Temperature Element for Process Measurement

1. General Requirements for T100 Series Intelligent Temperature Measuring Indicators/Transmitters apply to this type of instrument.

2. The Temperature Indicator/Transmitters shall have the following features:

a. Mounting: Remote from sensor.

3. The Sensor Element Thermowell shall have the following features:

a. Thermowell Insertion Length:

1) Pipe Installation: Equal to the radius (based on nominal diameter) of the process pipe in which thermowell is inserted. Maximum length of 36 inches.

2) Duct Installation: Equal to one-half the depth of the duct (the depth of duct parallel to the direction of insertion of the thermowell) of the process duct in which thermowell is inserted. Maximum length of 36 inches.

b. Sensor Assembly Connection: 1/2 inch NPT threaded to sensor.

c. Process Connection:

1) Thermowell Length 12 Inches or Less: 3/4 inch NPT threaded to process pipe.

2) Thermowell Greater Than 12 Inches: 1-1/4 inch NPT threaded to process pipe.

d. Terminal Enclosure:

1) NEMA-4X, polyurethane coated, die-cast aluminum.

2) Terminal blocks for termination of sensor and field wiring.

3) Extended height enclosure with field removable and gasketed cover.

4) Electrical Connection: 3/4 inch NPT threaded.

2.04 INTELLIGENT HUMIDITY MEASURING INDICATORS/TRANSMITTERS

A. H105: Requirements:

1. Humidity Measurement Range: 0 to 100% RH

2. Output Signal:

a. Nominal Output Range: 4 to 20 mA DC = 0% to 100% RH.

b. Minimum Output Current: 3.8 mA.

c. Maximum Output Current: 22 mA.

3. Sensing Element:

a. Humidity: Thin film capacitive element.

4. Temperature Effect: ±0.03% RH/°C ±1% from 10°C to 85°C

5. Operating Temperature: Transmitter: -4 to 176°F.

6. Storage Temperature: -58 to 185°F.

7. Conduit Connection: 1/2-inch NPT.

8. Supply Voltage: 16.5 to 28 VDC.

9. Voltage Effect: ±0.001% of span/volt from 9.5 to 28 VDC.

10. Accuracy: of Humidity Measurement: ±2.5% from 10% to 80% RH @ 25°C, ±3.5% from 80% to 90% RH @ 25°C with NIST certificate.

a. Accuracy statement above includes linearity, hysteresis, repeatability, and voltage effects.

11. Adjustments: Zero and Span field adjustments, non-interacting.

12. Time Constant: 50 seconds in slow moving air.

13. Connections: Screw terminals (22-14 AWG wire).

14. Weight: 4.46 lbs.

15. Filter: 60 micron stainless-steel sintered filter.

    a. Provide two (2) additional spare sintered filters in addition to the one installed in the instrument.

16. Probe Length: 6-inches.

17. Transmitter Rating: Explosion proof with intrinsically safe sensor.

18. Hazardous Area Classifications: Suitable for installation in the following areas:

    a. Class I, Division 1, 2, Groups B, C, D.

    b. Class II, Division 1, 2, Groups E, F, G.

    c. Class III, Division 1, 2.

19. Hardware: All bolts, process connections, and hardware shall be Type 316 Stainless Steel.

20. Local Indication:

    a. Local indicator (integral to Indicators/Transmitters) which is calibrated in "% RH", with any other relevant metrics in English units, and to the range of the transmitter (or to the range of the process variable range selected by the Owner).

    b. The indicator shall be of the digital type with liquid crystal display (LCD), driven by the loop power (4-20mA at 24 VDC).

21. Mounting Hardware: Manufacturer's Type 316 Stainless Steel mounting bracket suitable for mounting transmitter on 2-inch pipe stand, support channel, wall/panel or other surface as shown on PLANS. Refer to the PLANS for additional requirements.

22. Each Intelligent Humidity Measuring Indicator/Transmitter along with the associated accessories shall be as manufactured by Minco Model AH73 with the Model HT480 transmitter and Part Number AC103512 spare sintered filters and the specified manufacturer furnished accessories, or Engineer approved equal.

2.05 THERMAL DISPERSION AIR FLOW ELEMENT AND INDICATING TRANSMITTERS

A. F413: Thermal Dispersion Air Flow Element and Indicating Transmitters

1. General Requirements:

    a. Installed Airflow Accuracy:

        1) Ducts/Plenum: ±3% of reading.

        2) Non-ducted OA Intakes: better than or equal to ±5% of reading.

    b. Sensor Node Averaging Method:

        1) Airflow: Independent, arithmetic average

        2) Temperature: Independent, velocity weighted or arithmetic average

    c. Listings:

1) UL: UL 873 Listed

2) CE: European shipments only

d. Environmental Limits:

1) Temperature:

a) Probes: -20 to 160 degrees F [-28.9 to 71.1 degrees C]

b) Transmitter: -20 to 120 degrees F [-28.9 to 48.9 degrees C]

2) Humidity: (non-condensing)

a) Probes: 0 to 100%

b) Transmitter: 5 to 95%

2. Flow Indicating Transmitter Requirements:

a. Output Signal No. 1 – Flow Signal: 4-20ma analog output signal configured to indicate flow in cubic feet per minute, where 4 ma equates to 0 CFM and 20 ma equates to the maximum range of flow CFM as scheduled in Appendix A.

b. Output Signal No. 2 – Fail/Fault: 4-20ma analog output signal configured to indicate a system fail/fault when the output signal is 4 ma.

c. Power: 24 VAC.

d. Connector Receptacle Pins and PCB Connections: Gold-plated receptacle pins, PCB interconnects, PCB edge fingers, and test points.

e. User Interface: 16-character LCD display and 4 button interface.

3. Flow Element Requirements:

a. Type: Insertion mounted probes with the required number of nodes per probe arranged in an equal area pattern sized to installed duct work cross-sectional areas. Refer to PLANS for ductwork size/orientation and location of flow element along the length of duct work.

1) At a minimum, provide a flow element sensor element consisting of two (2) probes minimum with two (2) nodes minimum per probe.

2) Provide additional probes and nodes per probe as required for the installed ductwork cross-sectional area and per the manufacturer requirements to achieve stated accuracy requirements.

3) Review PLANS and locate upstream and downstream ductwork elbows and/or other restrictions and provide the necessary number of probes and nodes per probe to comply with the specified flow measurement accuracy requirements to accommodate the installed ductwork work conditions.

b. Construction: Type 316 Stainless Steel tube construction and Kynar sensor assembly housing.

c. Individual Sensing Nodes:

1) Sensing Node Sensors:

a) Self-heated sensor: Precision, hermetically sealed, bead-in-glass thermistor probe.

b) Temperature sensor: Precision, hermetically sealed, bead-in-glass thermistor probe.

2) Sensing Node Housing:

a) Material: Kynar with /SS

b) Sensor Potting Materials: Waterproof marine epoxy

3) Sensing Node Internal Wiring:

a) Type: Kynar coated copper.

4) Airflow Measurement:

a) Accuracy: ±2% of reading to NIST-traceable airflow standards (includes transmitter uncertainty).

b) Calibrated Range: 0 to 5,000 fpm.

c) Calibration Points: 16

5) Temperature Measurement:

a) Accuracy: ±0.15 degrees F to NIST-traceable temperature standards (includes transmitter uncertainty).

b) Calibrated Range: -20 to 160 degrees F.

c) Calibration Points: 3.

d. Sensor Probe Assembly:

1) Tube:

a) Material: 316 stainless steel

b) Mounting Brackets: Material: 304 stainless steel

2) Mounting Options & Standard Size Limits:

a) Insertion and Stand-off: 6 to 120 in.

b) Internal: 8 to 120 in.

c) Refer to PLANS for applicable installation requirements, including applicable duct work dimensions.

3) Probe to Transmitter Cables:

a) Type: FEP jacket, plenum rated CMP/CL2P, UL/cUL listed, -67 to 392 degrees F, UV tolerant

4) Sensor Cable Length:

a) Allow for up to a 50 foot sensor cable per probe.

b) Coordinate final length with installed field conditions.

c) Connecting Plug: 13/16” nominal diameter with goldplated connector pins.

4. Each Thermal Dispersion Air Flow Element And Indicating Transmitter shall be as manufactured by Ebtron with Model no. GTC116 flow indicator transmitter and Model no. GTX116-P+ probe, or Engineer approved equal.

5. Field Installed Enclosure for Flow Indicating Transmitter: Provide the following enclosure to house the flow indicating transmitter.

a. Windowed door enclosure with non-locking handle.

b. Each enclosure shall be as manufactured by Hoffman Engineering Co. Catalog No. C-SD20166WLG with C-P2016 Concept Panel, or Engineer approved equal.

2.06 HYDROGEN GAS ANALYZER AND INDICATING TRANSMITTERS

A. A107: Requirements

1. General:

a. Furnish gas analysis and indicating/transmitter for the detection of Hydrogen gas concentration and with integral auxiliary fail alarm relay.

b. Measure combustible gas concentrations using poison-resistant catalytic bead type sensors.

c. Provide in a dual condulet version to allow the sensor only to be mounted near the ceiling while the transmitter display and controls are mounted near finished floor.

1) Field installed flexible tubing shall be permanently installed to allow calibration gas to be fed to the sensor from the transmitter location.

2. Indicating/Transmitter Module:

a. General Performance:

1) Four-wire loop

2) Shall operate from power supplies of 12-30 VDC, 200 mA maximum.

3) Response Time: (T90) 10 seconds.

4) Accuracy: ±10% of value.

5) Electronic Repeatability: ±1%

6) Electronic Linearity: ±0.5%

7) Zero Drift: Less than 2% full scale per month

8) Span Drift: Less than 3% per month

9) Operating Temperature:

a) Toxic Gas Measurement: -30º to +60º C

b) Combustible Gas Measurement: -40º to +70º C

b. Local Indicator:

1) LCD local indicator (integral to gas Indicator/Transmitter).

2) Range: 0-100% LEL.

c. Operator Local Controls:

1) Provide operational interface for service personnel

2) Four (4) minimum controls to allow calibration functions, lock the 4-20mAdc output, or manually vary the output signal for test procedures.

d. Transmitter Output:

1) 4-20 mAdc insulated analog output linear to gas concentration.

2) Capable of driving external loads up to 1000 ohms with a standard 24 VDC supply.

3) Electrically isolated from ground and from all other internal circuits that are not isolated from ground.

4) Output isolation shall be provided by the transmitter.

e. Alarm Relays:

1) Three (3) SPDT Relays, each 5 A at 230 VAC resistive.

2) Relay coil programmable either normally energized or normally de-energized.

3) Alarms field programmable for Setpoint, Hysteresis, Alarm delay, Manual or automatic reset, and Instrument fault.

f. Instrument Enclosure:

1) Housed in explosion-proof enclosure with window.

2) Magnetic controls shall be operable through the enclosure window without removing the cover.

3) Transmitter and sensor shall meet explosion-proof specifications for Class 1, Group B, C, & D, Class 2, Groups E & F; and Class 3 locations.

g. Electronic Module:

1) The Combustible Gas transmitter electronic module shall be designed as plug-in unit that can be easily removed for service without disconnecting field wiring.

2) Modules shall be interchangeable, allowing immediate exchange of transmitter electronics in the event of a fault in a module.

h. Auto-Test Function:

1) Hydrogen generator shall be used to provide an Auto-Test function that will automatically test combustible gas sensors for response every 24 hours.

2) During sensor functional test, the transmitter output shall be held at 4 mA.

3) In the event that the Auto-Test detects a sensor failure, the output of the transmitter will go to 3 mA to provide remote trouble indication.

4) The electronic transmitter shall keep a test log and display the results of each test on the LCD display.

5) The log shall be accessible to operators through an information sequence activated by the front magnetic switches.

3. Sensor Module:

a. Housing/Assembly:

1) Housed in a 316 stainless steel housing with flame arrestor to meet explosion-proof requirements.

2) Contained in a housing that also incorporates an electrochemical hydrogen generator.

3) Sensing element assembly shall consist of factory furnished explosion proof junction box, combustible gas sensor and calibration adaptor.

4) Includes 1/4" barbed fitting calibration port to accept 1/4" outside diameter flexible PVC tubing.

b. Furnished with the following manufacturer accessories:

1) Splash Guard: Clear polycarbonate splash protection guard.

2) Calibration Adapter: for routine zero air and span gas calibration checks.

3) Flowcell Assembly: An assembly to allow for sample draw system in addition to monitoring a flowing sample stream.

4) Sensor Module Keeper (case).

5) Provide all required accessories including hardware to mounted transmitter and sensor.

c. The sensor module and the indicator/transmitter module shall be the product of the same manufacturer.

4. Gas Calibration Kit:

a. As minimum, the gas Calibration Kit shall include the following:

1) One (1) 103-Liter non-disposable gas aluminum cylinder filled with HYDROGEN calibration gas.

2) Mechanical Valve and Flowmeter assembly (inclusive of mechanical gauge) suitable for use with the gas cylinder.

3) Includes 1/4" barbed fitting gas discharge port to accept 1/4" outside diameter flexible PVC tubing fixed adjacent to transmitter.

4) Hard brief-case type calibration case made specifically for housing the Cylinders, mechanical valve and flowmeter assemblies, and all that is associated with the Calibration Kit.

b. The Calibration Kit shall be the product of the same manufacturer as the gas Indicator/Transmitter module and the Sensor module.

5. Each Indicator/Transmitter module shall be as manufactured by Analytical Technology, Inc. “Ati” Series D12 or Engineer approved equal Universal Gas Transmitter, complete with the specified accessories.

6. Each Sensor module shall be as manufactured by Analytical Technology, Inc. “Ati” Model UniSens or Engineer approved equal HYDROGEN gas sensor, complete with the specified accessories.

7. Each Gas Calibration Kit shall be as manufactured by Analytical Technology, Inc. “Ati” or Engineer approved equal complete with regulator.

2.07 TUBING, HAND VALVES AND FITTINGS

A. General: Refer to the PLANS for additional requirements for tubing, hand valves, fittings, etc. Provide tubing, hand valves, and fittings for pressure and differential pressure instruments and devices as shown. Provide as required for a functional installation.

B. Tubing:

1. Material: ASTM A-213 Type 316 Stainless Steel annealed seamless

2. Size:

a. Indoor (Inside Building): 3/8” outer diameter tubing with 0.035” wall thickness

b. Outdoor (Outside of Building): 1/2” outer diameter tubing with 0.049” wall thickness

c. Stand Pipe Ventilation or Other System Ventilation Piping: 1” outer diameter tubing with 0.109” wall thickness.

d. Provide other larger size(s) as shown on the PLANS.

3. Pressure Rating: 3,000 psi minimum working pressure at 100 degrees Fahrenheit

C. Metal fittings and Accessories:

1. Type: Swage ferrule design

2. Material: Type 316 Stainless Steel

3. Size: Same size as tubing

4. Pressure Rating: Same as tubing

5. Manufacturer: Crawford "Swagelok", Parker "CPI", Hoke "Gyrolok", or Engineer approved equal.

D. Valves:

1. Type: Full port ball valves
2. Material: Type 316 Stainless Steel trim and body
3. Seats and packing: Teflon
4. Size: Same size as tubing
5. Pressure Rating: Same as tubing
6. Manufacturer: Parker CPI, Whitey, Hoke, or Engineer approved equal.

E. Bleed Fitting/Valve:

1. Type: Swage ferrule or threaded process connection, as suited for application. Include vent tube and back stop screw. Provide handle. Provide barbed ventu tube where vent tube is piping to drain or other location where shown on PLANS.
2. Material: Type 316 Stainless Steel
3. Stem O-Ring: Fluoroelastomer.
4. Size: Same size as tubing
5. Pressure Rating: Same as tubing
6. Manufacturer: Crawford "Swagelok", Parker "CPI", Hoke "Gyrolok", or Engineer approved equal.

F. Provide stainless steel reducer/transition fittings at instrument/process piping and tubing connections.

G. Bulkhead Fittings:

1. General Requirements:
   a. Material: Type 316 Stainless Steel trim and body
   b. Size: Same size as tubing
   c. Pressure Rating: Same as tubing
   d. Manufacturer: Parker CPI, Whitey, Hoke, or Engineer approved equal.
2. Tubing to Tubing Unions:
   a. Fitting: Bulkhead Union, Hoke BU or Engineer approved equal.
   b. Connection Type, Both Ends: Swage ferrule design
3. Tubing to Test Port:
   a. Fitting: Bulkhead Union, Hoke BU or Engineer approved equal.
   b. Connection Type, Both Ends: Swage ferrule design
4. Tubing to Vent Screen Fitting:
   a. Fitting: Bulkhead Union, Hoke BU with or Engineer approved equal.
   b. Tubing Connection Type: Swage ferrule design with standard nut.

c. Screen Connection Type: Swage ferrule design with knurled nut, Hoke KN or Engineer approved equal.

H. Vent Screen Fittings:

1. Material: Type 316 Stainless Steel trim and body

2. Size: Same size as tubing or pipe vent screen fitting is connected to.

a. Available vent screen fitting sizes shall include 1/4", 3/8", 1/2", 3/4", and 1" in diameter.

b. Vent screen fitting shall be of equal diameter or the next listed size greater than the tubing/piping the vent screen fitting is connected to.

c. Provide reducer fitting between vent screen fitting and tubing/piping as required.

d. Where tubing/piping is larger than 1" diameter, provide 1" size vent screen fitting and necessary reducer fitting to connect to tubing/piping.

3. Pressure Rating: Same as tubing

4. Fitting: Screen, Hoke SCRN or Engineer approved equal.

5. Manufacturer: Parker CPI, Whitey, Hoke, or Engineer approved equal.

I. Provide stainless steel rigid to plastic flexible tubing transitions where shown on PLANS including stainless steel tube inserts and Teflon ferrule compression fitting.

J. Tubing Support System:

1. UNISTRUT Cush-A-Clamp Assembly Pipe/Tube Clamp (1-5/8" Series), or Engineer approved equal, with controlled squeeze shoulder bolt for all clamping of instrument tubing.

2. Refer to Specification Section 16150 "Raceways, Fittings, and Supports" for instrument tubing support channel system additional requirements.

PART 3 - EXECUTION

3.01 STORAGE AND HANDLING

A. The field instrumentation and control devices shall be handled carefully to prevent damage. Units shall be stored in a weatherproof structure prior to installation.

3.02 INSTALLATION

A. General: The following apply to all products in this Section:

1. Furnish and install devices in locations shown, and per the details provided in the PLANS, unless otherwise noted.

2. Unless otherwise specified, all instrument mounting channels, pipes, pipe caps, etc. shall be Type 316 stainless steel; also, all hardware connecting and securing

the mounting hardware and instruments such as nuts, bolts, instrument tubing Cush-A-Clamp Assembly Pipe/Tube Clamp etc. shall be Type 316 Stainless Steel. Refer to Division 16 Specifications for additional support system requirements.

3. All field mounted sensor/control/instrument devices shall be permanently identified. The device designations shall agree with those shown on the PLANS. Each device shall be provided with permanent type identifying nameplate. Nameplates, unless otherwise specified, shall be shaped as a circle and shall be constructed of 3-ply "White-Black-White" laminated phenolic material having engraved letters approximately 1/4 inch high extending through the white face into the black layer. Securely hang nameplates from each sensor/control/instrument device by a flexible stainless steel snap-on type hanger/key-chain cord (neatly drill a hole through the top of the identification nameplate for this purpose).

   a. All proposed instruments shall receive new permanent identification.

   b. All existing instruments shown on the PLANS that are to be relocated and/or to receive new wiring for signals/power/etc. as part of this Work shall also receive new permanent identification. Remove the existing identification tags from existing instruments that are to receive new tags.

4. Nameplates:

   a. Type: 3-ply, 1/8" thick, rigid thermoset phenolic resin laminated cellulose paper base engraving stock per ASTM D-709, Type I. Nameplates shall be ASTM Grade ES-1, ES-2, or ES-3 as applicable for the face and lettering colors specified hereinafter. Flexible or acrylic tags will be not be accepted.

   b. Color: White-Black-White

   c. Lettering: 1/4 inch height, minimum, engraved through the face layer to the melamine middle layer.

   d. Accessories: Provide holes for mechanical fastening.

   e. Attachment Means: Securely hang nameplates from each sensor/control/instrument device by a flexible stainless steel snap-on type hanger/key-chain cord (neatly drill a hole through the top of the identification nameplate for this purpose).

5. Submit listing of all field instruments tag numbers for verification by OWNER.

6. Install, set, adjust and test all devices per the requirements of Section 17100 of the Specifications. Also, setpoint values shall be reviewed by and coordinated with the OWNER/ENGINEER.

7. The pressure instruments specified under this Section of the Specifications shall be tested by applying known pressure to each unit prior to installation.

8. The instruments specified under this Section of the Specifications shall be installed and calibrated to match its respective system and per the requirements of the Contract Documents and as recommended by the manufacturers.

9. Verify ranges with Owner and Engineer prior to ordering instruments.

10. Refer to Specification Section 16150 “Raceways, Fittings, and Supports” for instrument support channel system requirements.

11. Make all final connections and terminations per the instrument manufacturers’ recommendations.

12. Unit and Range of each instrument from the Instrument shall be as listed in the Appendix A Instrument List and shall be clearly noted on the instrument Submittals. Instrument ranges shall be confirmed via the submittal process with the ENGINEER prior to ordering any of the Field Instrumentation and Sensing Devices specified under this Section of the Specifications. Select instruments within approved manufacturer series that provide the greatest level of accuracy within the span of measurements listed in the Instrument List.

13. Submit comprehensive calibration sheets to the OWNER indicating “as found” and “final settings”. Submit a typical (blank) field calibration sheets/forms to the OWNER for review and comment prior to utilizing the same for recording calibration parameters. Include final field calibration settings in the Operation and Maintenance Manuals.

14. Coordinate the installation with all trades to ensure that the mechanical system has all necessary appurtenances including weld-o-lets, valves, etc. for proper installation of instruments.

15. Provide manufacturer’s services to perform start-up and calibration/verification.

16. Verify factory calibration of all instruments in accordance with the manufacturer’s instructions. Return factory calibrated devices to the factory if they do not meet the field verification requirements for calibration.

B. Analyzers:

1. Install analyzers per the manufacturer requirements with all required kits/accessories to allow a complete and fully functional system.

2. Furnish and install the necessary mounting kit/pole/assembly necessary per the analyzer manufacturer requirements to allow the Owner to periodically remove the sensor element to clean/maintain/replace the sensor element.

3. Refer to the PLANS for additional requirements.

C. Pressure Instruments (Inclusive of Multivariable):

1. Testing:

a. The pressure instruments specified under this Section of the Specifications shall be tested by applying known pressure at 0%, 50% and 100% minimum increments of span to each unit prior to installation.

2. Air Duct Mounted Pressure Indicating Transmitters:

a. Fasten the transmitter on the exterior side of the duct with sheet metal screws.

b. Penetrate the duct and insert the transmitter manufacturer static duct probe.

c. Configure and install in accordance with the instrument manufacturer.

D. Thermal Dispersion Air Flow Element and Indicating Transmitters:

1. Install, calibrate and commission the flow indicating transmitter and the flow element per the manufacturer written instructions.

2. Provide all control and power connections.

3. Install the flow indicating transmitter in the specified enclosure and fasten with stainless steel screws to enclosure.

4. Configure the flow indicating transmitter display 4 significant digits of CFM airflow scaled from 0 to the maximum range of flow CFM as scheduled in Appendix A.

E. Hydrogen Gas Analyzer with Remote Mounted Indicating/Transmitters:

1. Indicating/transmitter shall be remote mounted separate from sensor.

2. Sensor shall be mounted as high as possible in the room and at least within 6” below highest roof deck of space.

3. Provide cable and conduit between sensor and transmitter.

4. Provide raceway system and required cable per instrument sensor factory requirements between sensor junction box and remote mounted indicating/transmitter.

F. Instrument Tubing:

1. Install tubing and supports so as not to interfere with work space/maintenance access of existing and proposed equipment.

2. Make all instrument tubing system connections air/water tight. Provide proper thread/joint sealant such as Teflon brand strips or other approved sealant where connecting to equipment/accessories/fittings.

3. Requirements herein relate to process pressure port taps/connections shall apply to flow-tube element (i.e. venturi, orifice plate, etc.)connections as well.

4. Tubing Support Systems (for Rigid and Flexible Capillary):

a. Clamp all instrument tubing onto channel supports. As a minimum, support and clamp all instrument tubing as follows:

1) Gas and Liquid Tubing: at 2’-6” intervals on horizontal and vertical runs, and no more than 3” from each elbow and tee fitting.

2) Capillary Tubing: at 12” intervals on horizontal and vertical runs.

3) Refer to PLANS for additional support requirements.

b. Provide suitable floor mounted or ceiling hung channel support systems necessary for mounting/fastening of instrument tubing.

c. Overhead or wall support systems for tubing shall be independent of other conduit/pipe support systems and shall solely support instrument tubing systems.

5. Instrument Tubing Conveying Air/Gas:

   a. Pressure port tubing connections to process piping and flow-tube elements shall be installed on the top crest position of horizontal process pipes and flow-tube elements.

   b. Horizontal runs of tubing installed higher than the process pipe/equipment tap connection shall be sloped 10% down towards the process pipe/equipment connection.

   c. Tubing installed lower than the process pipe/equipment tap connection, shall have a condensate drip leg and drain valve. Drip leg pipe segment shall be 6” long and located at the lowest portion of the instrument tubing. Install horizontal segments of the instrument tubing at a 10% slope down towards the drip leg.

6. Instrument Tubing Cutting and Fittings (Non-Capillary):

   a. Cut tubing with sharp cutting tool. Do not flatten tubing or in any way distort the manufacturer original tube diameter dimensions.

   b. File edges of tubing after cutting and remove any filings/shavings prior to making connections.

   c. Provide elbow fittings, tee fittings, reducer fittings, and valves at tube connections. Bending tubing in lieu of elbow fittings is not acceptable.

   d. Clean inside of tubes prior to operation. Clean by blowing out to ensure there is no debris in tubes.

G. The provided information does not necessarily include all required instruments. Provide all instruments identified in the Contract Documents. Instruments may be shown on the PLANS, in the Specifications or both.

3.03 OPERATION AND MAINTENANCE TRAINING

A. Start-up Training: Provide required instruction to the OWNER's personnel during start-up period.

B. Special Training School: Provide services of a factory-trained instructor or instructors for each of the specified and installed Field Instrumentation and Sensing Devices for a total period of not less than Two (2) working days for the purpose of instructing the OWNER’s personnel in the correct operating and maintenance procedures for all the Field Instrumentation and Sensing Devices specified under this Section of the Specifications and installed in this project. This is in addition to the training requirements defined in other Sections of Division 17 of the Specifications. The date of this school shall be scheduled with the OWNER, but will be after the entire instrument and control system is in operation and respective Operation and Maintenance Manuals have been submitted and revised per ENGINEER comments. Also, refer to the additional training requirements defined in other Sections of Division 17 of the Specifications.

   1. Provide one (1) month prior notice to schedule class events with OWNER.

2. Submit detailed listing of class curriculum including, as a minimum, with the following at least four (4) months prior to class:

   a. Specific topics for each instrument, including but not limited to, general trouble-shooting, calibration, wiring, and general set-up/configuration.

   b. Anticipated duration of class for each instrument type.

   c. Names of instructor(s) for each specific instrument.

   d. Refer to instrument by Instrument Type Code as listed in this specification section where applicable.

3.04 MEASUREMENT AND PAYMENT

No separate measurement or payment for work performed under this Section. All costs are included in the Base Bid.

END OF SECTION

ATTACHMENT "A" OF SECTION 17380
FIELD INSTRUMENTATION AND SENSING DEVICES
SOUTH AUSTIN REGIONAL
WASTEWATER TREATMENT PLANT
ELECTRICAL SUBSTATION NO. 1 REPLACEMENT

INSTRUMENT LIST

INSTRUMENT TAG	INST. TYPE CODE	SPEC. SECT.	PROCESS AREA	COMPONENT TITLE	MIN. VALUE	MAX. VALUE	MEAS. UNIT	INSTALLATION DETAIL DRAWING	PLAN DRAWING	WIRING SCHEMATIC DRAWING	P&ID DRAWING	COMMENTS
SUB1-AITC-1401 SUB1-AE-1401	A107	17380	SUBSTATION NO. 1	SUBSTATION NO. 1 HYDROGEN CONCENTRATION ANALYSIS INDICATING TRANSMITTER CONTROLLER	0	1500	PPM	[TD-I-001]	[SUB1-H-003]	[SUB1-I-002]	[SUB1-I-005]	
SUB1-TIT-1402	T103	17380	SUBSTATION NO. 1	SUBSTATION NO. 1 ELECTRICAL EQUIPMENT SPACE AMBIENT AIR TEMPERATURE INDICATING TRANSMITTER	0	200	F	[TD-I-001]	[SUB1-H-003]	[SUB1-I-002]	[SUB1-I-005]	
SUB1-AIT-1403	H105	17380	SUBSTATION NO. 1	SUBSTATION NO. 1 ELECTRICAL EQUIPMENT SPACE AMBIENT AIR HUMIDITY ANALYSIS INDICATING TRANSMITTER	0	100	% RH	[TD-I-001]	[SUB1-H-003]	[SUB1-I-002]	[SUB1-I-005]	
SUB1-TIT-1404	T103	17380	SUBSTATION NO. 1	SUBSTATION NO. 1 CONTROL EQUIPMENT SPACE AMBIENT AIR TEMPERAUTRE INDICATING TRANSMITTER	0	200	F	[TD-I-001]	[SUB1-H-003]	[SUB1-I-002]	[SUB1-I-005]	
SUB1-AIT-1405	H105	17380	SUBSTATION NO. 1	SUBSTATION NO. 1 CONTROL EQUIPMENT SPACE AMBIENT AIR HUMIDITY ANALYSIS INDICATING TRANSMITTER	0	100	% RH	[TD-I-001]	[SUB1-H-003]	[SUB1-I-002]	[SUB1-I-005]	
SUB1-TIT-1406	T103	17380	SUBSTATION NO. 1	SUBSTATION NO. 1 "SUB1-MCP-001" INTERNAL AIR TEMPERATURE INDICATING TRANSMITTER	0	200	F	[TD-I-001]	[SUB1-E-051]	[SUB1-I-003]	[SUB1-I-005]	
SUB1-TIT-1407	T103	17380	SUBSTATION NO. 1	SUBSTATION NO. 1 "SUB1-MCP-001" INTERNAL AIR TEMPERATURE INDICATING TRANSMITTER	0	200	F	[TD-I-001]	[SUB1-E-051]	[SUB1-I-003]	[SUB1-I-005]	
SUB1-FIT-1411 SUB1-FE-1411	F413	17380	SUBSTATION NO. 1	SCRUBBER NO. 1 OUTSIDE AIR FLOW INDICATING TRANSMITTER	0	3000	CFM	[SUB1-H-008]	[SUB1-H-004]	[SUB1-I-004]	[SUB1-I-006]	
SUB1-TIT-1412 SUB1-TE-1412	T118	17380	SUBSTATION NO. 1	SCRUBBER NO. 1 OUTSIDE AIR TEMPERATURE INDICATING TRANSMITTER	0	200	F	[TD-H-004]	[SUB1-H-004]	[SUB1-I-004]	[SUB1-I-006]	

INSTRUMENT TAG	INST. TYPE CODE	SPEC. SECT.	PROCESS AREA	COMPONENT TITLE	MIN. VALUE	MAX. VALUE	MEAS. UNIT	INSTALLATION DETAIL DRAWING	PLAN DRAWING	WIRING SCHEMATIC DRAWING	P&ID DRAWING	COMMENTS
SUB1-PDIT-1413	P203	17380	SUBSTATION NO. 1	SCRUBBER NO. 1 PRE-FILTER AIR PRESSURE DIFFERENTIAL INDICATING TRANSMITTER	0	2	IN. H20	[TD-H-004]	[SUB1-H-004]	[SUB1-I-004]	[SUB1-I-006]	
SUB1-PDIT-1414	P203	17380	SUBSTATION NO. 1	SUBSTATION NO. 1 FINAL-FILTER AIR PRESSURE DIFFERENTIAL INDICATING TRANSMITTER	0	2	IN. H20	[TD-H-004]	[SUB1-H-004]	[SUB1-I-004]	[SUB1-I-006]	
SUB1-PIT-1415	P303	17380	SUBSTATION NO. 1	AIR CONDITIONING UNIT NO. 1 SUPPLY DUCT PRESSURE INDICATING TRANSMITTER	0	1	IN. H20	[SUB1-H-006]	[SUB1-H-004]	[SUB1-I-003]	[SUB1-I-005]	
SUB1-FIT-1421 SUB1-FE-1421	F413	17380	SUBSTATION NO. 1	SCRUBBER NO. 2 OUTSIDE AIR FLOW INDICATING TRANSMITTER	0	3000	CFM	[SUB1-H-009]	[SUB1-H-005]	[SUB1-I-004]	[SUB1-I-006]	
SUB1-TIT-1422 SUB1-TE-1422	T118	17380	SUBSTATION NO. 1	SCRUBBER NO. 2 OUTSIDE AIR TEMPERATURE INDICATING TRANSMITTER	0	200	F	[TD-H-004]	[SUB1-H-005]	[SUB1-I-004]	[SUB1-I-006]	
SUB1-PDIT-1423	P203	17380	SUBSTATION NO. 1	SCRUBBER NO. 2 PRE-FILTER AIR PRESSURE DIFFERENTIAL INDICATING TRANSMITTER	0	2	IN. H20	[TD-H-004]	[SUB1-H-005]	[SUB1-I-004]	[SUB1-I-006]	
SUB1-PDIT-1424	P203	17380	SUBSTATION NO. 1	SCRUBBER NO. 2 FINAL-FILTER AIR PRESSURE DIFFERENTIAL INDICATING TRANSMITTER	0	2	IN. H20	[TD-H-004]	[SUB1-H-005]	[SUB1-I-004]	[SUB1-I-006]	
SUB1-PIT-1425	P303	17380	SUBSTATION NO. 1	AIR CONDITIONING UNIT NO. 2 SUPPLY DUCT PRESSURE INDICATING TRANSMITTER	0	1	IN. H20	[SUB1-H-007]	[SUB1-H-005]	[SUB1-I-003]	[SUB1-I-005]	

SECTION 17600

DISTRIBUTED CONTROL SYSTEM

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment, and incidentals required, and shall install complete, ready for operation, and test the distributed control system, hereinafter termed the System as shown on the PLANS and as specified.

B. The ICS shall provide equipment, materials, software, calibrations, training, and services that are required to successfully interface and interconnect the System and associated equipment that are specified or designated in drawings or provisions of these specifications for the purpose of providing a fully integrated and functional control system as specified.

C. The ICS shall furnish and install cabling and cable accessories, including tools necessary for connecting the System and peripherals, PLCs, data highway, and input/output devices.

D. The ICS shall furnish startup assistance, training, and system check-out services.

E. The ICS shall be responsible for furnishing and installing the Communication System for the Distributed Control System "DCS" (installation and testing of the fiber optic cable, transceivers and validation of communication system) as required and specified hereinafter.

F. The subsequent document entitled "Appendix A – PLC Input/Output Schedule" is hereto made part of this section and includes a listing of proposed PLC input/output interface points and other requirements. This schedule in "Appendix A" is not inclusive of all equipment required by this Contract. Refer to other subsections of this Specification Section for additional requirements in addition to those listed in "Appendix A".

1.02 DISTRIBUTED CONTROL SYSTEM DESCRIPTION

A. General: the Distributed Control System (DCS) as shown on the PLANS and specified herein, consists of Programmable Logic Controllers Subsystem (PLCs), existing Personal Computers/Workstations "PC", and Communication System, Application and System Software, and PLC networking/data communications over a Modbus Plus, Fast Ethernet, and Gigabit Ethernet.

B. The communication link between PLCs and the SCADA Top-End Computer System shall consist of a dual channel Fast Ethernet network arranged in a star configuration, over a system of Ethernet Network Switches, as shown in the PLANS.

C. The communication links between the PLC's and the Power Monitoring Units (PMUs), and between the PLC's and the Feeder Management Relays (FMRs) shall consist of a single channel Ethernet network as shown on the PLANS.

D. Remote I/O links shall at minimum operate at 100 Mbps data transmission rate.

E. PLC Manufacturer.

1. The Type 1 PLCs system design shown on the Contract Drawings and specified herein shall be Schneider Electric, Telemecanique, BMX M580 Automation Series. Unless otherwise noted, all PLCs shall be assumed to be Type 1 PLCs.

F. The PLCs shall be housed in the applicable Main Instrument and Control Cabinets as shown on the PLANS. The respective Control Panel shall also house the Fiber-Optic patch panels, Uninterruptable Power Supplies (UPS), I/O Subsystems, and networking equipment associated with communication with remote PMUs and FMRs. Refer to PLANS.

G. Refer to requirements of Section 17100.

1.03 RELATED SPECIFICATIONS

A. Refer to Section 17100.

B. This Section covers work related to the Distributed Control System DCS and its Subsystems. Note that this Section does not stand alone. Many key technical definitions, functional requirements, training, submittals, etc. requirements for the DCS are given in Section 17100 "Process Instrumentation and Control System PICS".

1.04 DISTRIBUTED CONTROL SYSTEM (DCS) SUBMITTALS

A. Hardware: Provide the following for all elements of the PLCs:

1. Block Diagram: A diagram showing all major PLCs components. Identify components by manufacturer and model number. Show interconnecting cables diagrammatically.

2. Bill of Materials: A list of all PLCs components. Group components by type and include:

a. Component manufacturer, model number, and part number.

b. Component description.

c. Quantity supplied.

d. Reference to component catalog information.

3. Descriptive Information: Catalog information, descriptive literature, performance specifications, internal wiring diagrams, power and grounding requirements, power consumption, and heat dissipation of all elements of the PLCs. Clearly mark all options and features proposed for this project.

4. Interconnecting Wiring Diagrams: Diagrams shall show all PLCs elements, their interconnecting cables and wiring terminations, and all terminations to all interacting elements and subsystems. Terminations shall be numbered. The I/O point numbers and

terminations for circuits extending outside the PLCs shall be numbered/labeled the same as those shown on the PLANS.

5. Installation Details: Any modifications or further details as may be required to supplement the Contract Documents and adequately define the installation of the PLCs elements.

6. Input/Output List: Provide for each I/O point list point type, tag number of the source or final control element, equipment description, PLC number, PLC terminal identification, and PLC address.

7. PLC I/O Spreadsheets

    a. The Owner has a standard Excel spreadsheets template of enumerating information abou the I/O points for the installation of the system. Upon completion of the system installation and PAT, the Owner shall supply to the ICS an I/O spreadsheets template in Excel format for the contractor to complete.

    b. The Contractor is to complete and submit in Excel format the Owner provided I/O spreadhseets template.

8. List of spare parts and expendables provided.

9. List of additional spare parts recommended.

B. Fiber-Optic Cable Plant Design: Submit fiber-optic cable types, installation procedure, cable splicing procedures, splicing locations, and fiber flux budget/gain margin calculations.

C. Pre-software Development Submittal: Provide a complete set of standard user's manuals for the PLCs. These manuals shall cover all aspects of programming, documenting, and using the PLCs equipment. In particular, the documents shall include information about the NOE ethernet module.

D. Operations and Maintenance O&M Manuals:

1. Hardware: As minimum, provide the following:

    a. Final approved versions of all shop drawing submittals.

    b. Component Manufacturers' O&M Manuals including manuals to cover installation, operation, maintenance, troubleshooting, and calibration.

    c. List of spare parts and expendables provided and list of spare parts recommended.

2. Software: As minimum, provide the Component manufacturers' latest version of the programming manuals for the Unity Pro XL Programming interface and IEC programming languages. Also provide the OIU manufacturers standard programming manuals and latest version of the I/O drivers and the screen development and configuration software

E. Fiber Optic Cable Testing Submittal: Provide a complete set of fiber optic cable test results for the testing required under subsection 3.02 "Fiber-Optic System – Source Quality Control", this Section of the Specifications. Format and quantity of reports shall be per the requirements of Section 01300 of the Contract Specifications Provide the OWNER with a typewritten results of all tests, including a description of the equipment tested, the date and time of day tested, test values, results. Test reports shall be signed by the ICS representative. All testing results, including all fiber optic and copper cable test results, as further identified in these specifications.

F. Copper Cable Testing Submittal: Provide a complete set of fiber optic cable test results for the testing required under subsection 3.03 "Copper Ethernet Cable System Testing – Source Quality Control", this Section of the Specifications. Format and quantity of reports shall be per the requirements of Section 01300 of the Contract Specifications Provide the OWNER with a typewritten results of all tests, including a description of the equipment tested, the date and time of day tested, test values, results. Test reports shall be signed by the ICS representative.

G. All Proposed Training Courses Descriptions and Course Material, as further identified in Part 4 of this specification section.

H. Refer to submittal requirements of Specifications Section 17100, Section 01300 and Section 01730 of the Contract Specifications.

I. Refer to the requirements of Specifications Section 17100.

PART 2 - PRODUCTS

2.01 GENERAL

A. Refer to Section 17100.

B. Equipment shall be designed to operate on a 60 Hertz alternating current power source at a nominal 120 volts, plus or minus 10 percent, except where specifically noted. Regulators and power supplies required for compliance with the above shall be provided. Where equipment requires voltage regulation, constant voltage transformers shall be supplied.

C. Materials and equipment used shall be U.L. approved wherever such approved equipment and materials are available

2.02 PROGRAMMABLE LOGIC CONTROLLERS (PLCS) - FUNCTIONAL REQUIREMENTS

A. General

1. The PLCs shall be used for data acquisition and control. The operations described hereinafter are intended to identify minimum acceptable performance. The Contractor shall provide all hardware and software features required to make the PLCs totally operational.

2. A suggested Process Control System block diagram including Programmable Logic Controllers locations is shown on the PLANS.

B. Availability

1. Subsystem Availability Calculation: The Subsystem availability (A) for the PLCS is defined as average of the individual PLC availabilities (Ai) times the nonspecific availability (NA). That i, A = NA*(Al*A2*A3 ... *An)/n, where n is the number of PLC's.

2. Availability Requirements: The PLCs availability shall be at least 99 percent.

3. Component and Backup Definitions: For purposes of the availability calculations, each PLC, each PLC power supply, its process I/O, and data highway interface is considered to be an individual component. There are no backup components.

C. Communications

1. General:

a. Provide a high speed peer-to-peer, dual channel, communications system to link all Programmable Logic Controllers PLCs.

b. Through the data highway, the operator interface workstations PCs shall have access to all process I/O points handled by each PLC and all internal data base parameters. This access shall also allow for changes by the PCs to all PLC process outputs and registers.

c. Failure of any PLC or DCS component connected to the communications system network shall not affect the ability of the remaining components on the network to communicate with each other.

2. PLCs Communications:

a. The communications system shall link PLCs, remote I/O modules (RIO), and the central processing units (CPU) with the PCs of the DCS via a system of fiber-optic links, communication controllers, cables, and connectors. Refer to the PLANS.

b. That portion of the communications system that links the PLCs and the Top-End computer is referred to as a "Data Highway," DH herein. The communications links between PLCs and their RIO are referred to as "Remote Network" RN herein.

c. Data Highway DH links shall consist of a dual channel Fast Ethernet (100BaseFX) and dual channel Gigabit Ethernet (1000BaseLX/LH).

d. The Remote Network RN links shall at minimum operate at 100 Mbps data transmission rate.

e. The Ethernet dual channel Fiber Optic network consists of two (2) redundant fiber optic cable systems that are each independently routed for each link between Gigabit and Fast Ethernet Fiber Optic communication devices, as shown on the Drawings. In

the event of loss of one cable, the other cable shall be capable of performing all necessary communication tasks without loss of data integrity or throughput. The Gigabit Ethernet portion of the network shall interconnect the plant's Ethernet Switches via their GBIC or SFP respective modules or Gigabit uplink ports.

f. The Copper Fast Ethernet Portion of the system shall consist of two (2) electrically redundant cable systems that are each independently routed for each link between Fast Ethernet communication devices, as shown on the Drawings. In the event of loss of one cable, the other cable shall be capable of performing all necessary communication tasks without loss of data integrity or throughput. The Fast Ethernet portion of the network shall include media converters, the PLC's, the plant SCADA Top-End computers, the Ethernet Switches, and the OIU's.

g. The fiber-optic link shall be designed to ensure a minimum gain margin of 4 dB. The Flux Budget/Gain margin is the difference between the system gain of the fiber-optic transmitter/receiver and the calculated loss budget of the fiber-optic link (fiber-optic cable, connectors, patch cords, and splices) when both are expressed in decibels (dB)).

h. Each proposed device communicating on the Gigabit Ethernet network shall consists of at least two (2) independent SFP modules 1000BaseLX/LH, each attached to a cable of the dual cables of the Gigabit Ethernet portion of the DH. Each module shall consist of its own independent communication subsystem, each simultaneously communicating with the respective module of other 2 module devices over the DH.

i. The remote I/O shall be single channel, Ethernet, in a ring network topology. All remote I/O cabling and installation shall be in accordance to the Modicon M580 System Planning Guide.

j. The PLC shall be the host of a Modbus TCP/IP network attached to Power Metering Units "PMUs" and/or Feeder Management Relays "FMRs" furnished with the electrical distribution equipment (refer to Division 16 - Electrical Specifications of the Specifications).

k. All copper Ethernet cables shall have a category 6A RJ-45 connector and category 6A cable. The connector end shall be the Boot type connector and preinstalled by the Ethernet patch cable manufacturer. The Ethernet cable outer jacket shall be the color Blue.

l. All communication cabling, including Ethernet, Remote I/O, etc., shall be tagged at both ends, similar to the wire tagging methodology described under Section 16200 of the Specification. The tagging for the communication cables shall be the Thermal Transfer, Industrial Rated, Self Laminating Type, as manufactured by Raychem (Tyco Electronics Identification). The tag length shall be a minimum of 2-inches. Provide the necessary thermal transfer printer for the printing of tags. Refer to Section 16200 for further detail regarding tagging.

2.03 PROGRAMMABLE LOGIC CONTROLLERS (PLCS) - GENERAL EQUIPMENT SPECIFICATIONS REQUIREMENTS

A. General

1. All components and interconnecting wiring shall be provided as required to satisfy the functional and operational requirements of this Specification.

B. Power Supply

1. PLCs equipment shall operate on 120-volt ac, plus or minus 10 percent, single-phase, 60-Hz, plus or minus 0.5-Hz power. The 120V ac power source may have transient impulses of plus or minus 100 volts for up to 2 milliseconds, and line voltage dropouts of up to 15 cycles.

2. Provide an Uninterruptible Power Supply (UPS) to serve each PLC and RIO, sized as required, to provide the power backup quality and time specified in Section 17200 of these Specifications. UPS shall also power all components associated with that PLC or RIO including, but not limited to, fiber-optic and data communication equipment. Assume 100 percent of output relays assigned to the PLCs are energized.

C. Communication Cables, Terminations and Splices

1. Communication Cables: Provide all cables for interconnection between all components of the DCS inside the and/or in duct/conduit banks, as applicable. These cables shall include cables to the PLCs I/O racks, power supplies, central processing units, fiber-optic components, PCs, Modems, etc. Also refer to fiber-optic communications requirements listed in this specification section.

D. Ethernet Switches

1. Fiber Optic Connectors associated with Devices: The SFP modules shall utilize an LC duplex single mode type connector. The GBIC modules shall utilize an SC duplex single mode type connector.

2. All communication cables routed to Ethernet switches shall be of sufficient length such that each communication cable may be connected to any port of the switch, with a remaining minimum slack of 1 foot in the cable after installation.

E. Equipment Configuration

1. The PLCs shall include, but not be limited to, the equipment components called for on the PLANS and in these specifications. Capacities and/or quantities shown are minimums. Provide additional capacity or units as necessary to meet the functional requirements.

2. Detailed descriptions equipment components are given in subsection Hardware Components Specifications.

F. Configuration System

1. Provide a configuration system, including hardware, system software, and other software necessary to allow Engineer configuration of and programming of the PLC system. PLCs equipment provided as part of the Configuration System shall be fully compatible with the DCS equipment provided for this system.

2. Ship and temporarily install the Configuration System at the Engineer's designated facility.

3. Include at least the following components for the Configuration System:

    a. All proposed Programmable Logic Controllers (PLCs), including all racks, power supplies, microprocessor modules, I/O modules, communication modules, remote I/O modules, etc.

    b. All laptops.

    c. All proposed Remote I/O units, including all racks, power supplies, I/O modules, communication modules, remote I/O modules, etc.

    d. All Operator Interface Units (OIU's) as well as software license and key for each OIU.

    e. All Communications interface hardware, including switches, cabling, and fiber optics electronics for PLC-to-PLC interface, and PLCs to programmer PC interface.

    f. All Remote Distributed I/O Systems, including base modules and extension modules.

    g. Two (2) Uninterruptible power supplies with sufficient capacity for the PLC rack, remote I/O rack(s) and all associated I/O cards, and communication equipment.

    h. Provide the following equipment for a Type 1 PLC: PLC CPU module, two (2) NOE modules, 16 slot rack, power supply, and two (2) digital input, two (2) digital output, two (2) analog input, two (2) RTD modules if the RTD module of this type is shown on the drawings, and two (2) analog output modules if the analog output module of this type is shown on the drawings. These equipment shall be independent of the PLC equipment to be installed in the field and shall in no way impede the ICS progress of work in wiring to the PLC modules. These may be counted among the spare PLC equipment to be purchased.

    i. Provide one (1) GE Multilin 850 unit with the Ethernet communication capability, per specifications, and one (1) GE Multilin 845 unit complete with the Ethernet communication capability, per specifications to be included with the configuration system. These units may be counted amongst the spare units.

    j. Provide 19" rack(s) and install PLC racks and other configuration equipment on 19" rack(s). For each 19" rack, secure rack to base with four (4) lockable, caster wheels that shall allow the cabinet to be pushed/carted forward, backward, and rotated at least 90 degrees. Overall rack assembly height shall not exceed 60".

    k. Prior to assembly and delivery of configuration system, submit to engineer a drawing detailing the front and back elevations of proposed arrangement of PLC equipment

on 19” rack(s). Upon approval of submittal, contractor is to then configure rack according to approved submittal and ship configuration system to Engineer’s location.

l. When directed by the Engineer, recreate and ship Configuration System from the Engineer’s designated facility to Owner’s facility.

m. Provide property and shipping insurance and include the Engineer and Owner as insured. Insure against fire and all-risk for physical loss and damage. The Owner and Engineer will not provide insurance for the Configuration System.

4. After completion of PAT, all software licenses procured for this project shall be registered in the name of the owner.

G. Spares and Expendables and Test Equipment

1. Provide the following Spare equipment:

a. Two (2) spare PLC processor units (CPU Modules) for each Type of PLC specified, with spare memory cards for each CPU.

b. A minimum of Ten Percent of the Number of PLC power supply units, with a minimum of Two (2), for each Type of power supply and PLC specified.

c. A minimum of Ten Percent of the Number of each size PLC back plane, with a minimum of One (1) of each kind, for each Type of PLC specified.

d. A minimum of Ten Percent of the Number of each type of I/O Module shown on the drawings, with a minimum of two (2) of each kind, for each Type of PLC specified.

e. A minimum of Ten Percent of the Number of each type of PLC network communication Modules (NOM, NOE), with a minimum of two (2) of each kind, for each Type of PLC specified.

f. A minimum of Ten percent of each remote I/O controller head processor, and remote I/O drop processor, but not less than two (2) of each type, for each Type of PLC specified.

g. Provide twelve (12) SC-Duplex to SC-Duplex fiber patch cords, for each Type of Fiber Optic cable specified.

h. Provide eight (8) LC-Duplex fiber patch cords.

i. Provide one (1) spare OIU unit complete with all accessories, as described in these specifications.

j. Provide one (1) spare Ethernet Switch of each type as described in these specifications, complete with all accessories.

k. Provide two (2) spare SFP 1000BaseLX/LH Modules as described in these specifications.

2.04 PROGRAMMABLE LOGIC CONTROLLERS (PLCS) - HARDWARE COMPONENT SPECIFICATIONS

A. Programmable Logic Controllers PLCs: Each programmable logic controller shall consist of central processor, process controller, power supply, memory, input/output, interconnecting cables, and optional items as specified.

1. General Specifications requirements for the PLCs are:

   a. Operating Temperature: 0 to 60 degrees C

   b. Humidity: 5 to 95% noncondensing

   c. Operating Voltage: 120 volts, 60-Hz ($\pm$ 10%)

B. Type 1 PLC:

1. Central Processor Units (CPUs) shall be as follows:

   a. The controller shall consist of a minimum of 65535 Kbytes memory.

   b. The controller shall consist of 1 mini B Universal Serial Bus (USB) port, 2 Ethernet Modbus TCP/IP port ports to support both RIO and DIO scanner, and 1 Ethernet Service Port for DIO devices, Unity, CNM, HMI, SCADA, diagnosis and external tools.

   c. The control shall be the MODICON BMEP58 6040 processor as manufactured by Schneider Electric

2. Input/Output: The input/output subsystem shall consist of all of the hardware for the CPU to communicate with the specified types of input and output modules. The input/output system shall consist of a communications interface module, an I/O controller, I/O base controller, I/O base, and the I/O modules. I/O throughput between the CPU and the I/O modules shall not be less than 1.0 Mbps.

3. Remote I/O Drop Card: Remote I/O Drop Card Shall be Modicon TSX X80 Automation Series Single-Cable, ring network topology configuration Ethernet Remote I/O Drop Adapter. The remote I/O drop card provides the interface between the remote I/O Rack and the respective remote CPU rack. The Remote I/O drop card shall be the X80 series BMECRA31210, as manufactured by Schneider Electric.

4. PLC Rack Extender System:

   a. Where shown on plans, furnish and install PLC rack extender system. Rack extender system shall be furnished and installed complete with all required cables, modules, and terminators per recommendations and requirements of Schneider Electric.

   b. Cable: Furnish and install extender cord, length as required per PLANS, manufactured by Extender Module manufacturer, model number BMX XBC series as manufactured by Schneider Electric.

c. Rack Extender Module: MODICON M340 Automation Series model number BMX XBE 1000 as manufactured by Schneider Electric for each rack interconnected by Rack Extender System.

5. Discrete Input Module DI:

   a. The programmable control system discrete inputs DIs shall be 120-volt ac, 60-Hz, with 16 points per module. The number and wiring to each active and spare DI point and module shall be per the requirements of the I/O point wiring schematics shown on the Contract Drawings. All 120-volt ac power to input/output modules shall have secondary surge protectors conforming to the requirements of IEEE Standard 28-1972 (ANSI C62.1-1971). Each point on DI modules shall have LED indication of ON/OFF status.

   b. Individual input point shall be capable of withstanding low energy common mode transients to 1,500 volts without catastrophic failure.

6. Discrete Output DO:

   a. The programmable logic controller system discrete outputs DOs shall all be isolated Form A contacts (relay output), rated 3-amps at 120volt ac, 60-Hz suitable for driving relays, solenoid operated valves, actuating motors starters, and similar inductive loads. Each output module shall consist of 8-individually isolated Form-A contacts, as shown on the Contract Drawings. Each point on DO modules shall have LED indication of ON/OFF status

   b. The output modules shall be protected form damage by inductively generated, NORMAL mode, and LOW energy common mode transients to 1,500 volts peak. The isolated discrete outputs shall open when a PLC failure is detected.

   c. Discrete output modules shall have individual status lights for each output point, and shall have barrier type terminal blocks for termination of the input/output wires. The module shall be constructed such that the field wires do not have to be removed (and physically disconnected from the respective terminals) while replacing the module.

7. Analog Input Module AI:

   a. The programmable control system analog inputs AIs shall be suitable for accepting a 4-20mA dc, -5V to 5V dc, 1V to 5V dc, 0 to 20mA dc signal, with 8-individually isolated points per AI module; i.e. no single ended or common analog signals shall be allowed. The input shall have an accuracy of plus or minus 0.3 percent of full scale. The input shall be capable of withstanding low common mode transients of 1,400 volts peak without catastrophic PLC failure.

   b. Furnish and install 28-pin Screw-type terminal block, Schneider Electric BMX FTB 2800 for each AI module.

8. Analog Output Module AO:

   a. The programmable control system analog outputs AOs shall be 4-20mA dc, with 4-individually isolated points per AO module; i.e. no single ended or common analog

signals shall be allowed. The 4-20mA dc outputs shall be suitable for driving into a 0 to 600 ohm load with an accuracy of plus or minus 0.25 percent of full scale

9. The Type 1 PLC I/O subsystem shall be Modicon X80 Series.

10. Network Option Ethernet (NOE): Each PLC rack which consists of a CPU, shall also consist of two (2) Ethernet Modules, where each such module is an Ethernet interface device as follows

    a. Each module shall contain a minimum of 1 10/100BaseTX port with an RJ-45 connector

    b. The Ethernet communication shall be Full Duplex capable

    c. Each Ethernet module shall have support for TCP services, including: FTP server, BOOTP server, SNMP V2 agent, MODBUS TCP/IP client, MODBUS TCP/IP server, and I/O Scanner.

    d. The Ethernet Module shall be the Modicon Automation Series model number BMENOC0311 Module as manufactured by Schneider Electric.

    e. Should a PLC rack have three (3) or more Network Option Ethernet modules, then the PLC rack power supply shall at minimum be the Schneider Electric CPS 4002 power supply.

11. RTD Module:

    a. The programmable control system RTD analog input module shall consist of four (4) input channels, with each channel suitable for accepting and each independently programmable for 2, 3, and 4 wire RTD inputs. Each channel shall at minimum be capable of accepting and each independently programmable to support the following RTD types:

        1) IEC Platinum 100 and IEC Platinum 1000, each with a corresponding input channel measurement range of –200°C to 850°C.

        2) American Platinum 100 and American Platinum 1000, each with a corresponding input channel measurement range of –100°C to 450°C.

        3) Nickel 100 and Nickel 1000, each with a corresponding input channel measurement range of –60°C to 180°C.

    b. The module shall posses a minimum of 750V channel to channel isolation and 1400V isolation between channel and bus.

    c. Each input channel of the module shall have an accuracy of plus or minus 0.15 percent of full scale over the entire RTD module's ambient operating temperature range of 0°C to 60°C.

d. Accessories: Provide an RTD extension module for each RTD module provided, model number MODICON model number Telefast ABE-7CPA412. Provide an extender cord, length as required per PLANS, model number BMX FCW series.

12. Rack: The PLC rack shall have both the X Bus and Ethernet Bus interface backplane. Refer to the drawings for the rack size.

13. I/O Module Terminal Blocks

a. With exception to the RTD and AI modules, furnish and install for each I/O module the Screw clamp terminal blocks, accepting up to two (2) AWG 15 wires per terminal, model BMXFTB2010 by Schneider Electric.

C. PLC Racks

1. All PLC racks shall be 16, 12, or 10 slot racks as indicated on the PLANS.

2.05 ETHERNET SWITCHES

A. Provide and install Ethernet switches for the Distributed Control System DCS. The ICS shall schematically design the routing and specify component make and model. The components herein shall be provided as minimum for bidding purposes.

B. All switches shall be provided with the latest firmware from the manufacturer, where applicable.

C. All switches shall be supplied with the manufacturers support contract for the duration of two years starting from final completion of the project. At minimum switches manufactured by Cisco shall have the Cisco SMART NET for a minimum of two (2) years starting from final completion of the project.

D. Should an Ethernet Switch, or component thereof, be end of life or scheduled to be end of life by the Ethernet Switch manufacturer at the time of bid, then furnish and install the part number and model as recommended by the manufacturer as a replacement for the part number and model which is indicated in this specification section.

E. All Ethernet switches of the same type shall be of the same switch manufacturer's software revision. In particular, switches manufactured by Cisco and of the same type shall be of the same IOS revision. Switches to be stacked must be supplied with the same feature set, IP LAN, IOS, etc.

F. Type 1 Ethernet Switch:

1. Power Input: 120 volts A.C., 60 Hz. Unit shall be equipped with its own power supply.

2. Port Quantity and Type: 24 10/100/1000Base TX ports, 4 of which are dual purpose ports which the user may elect to use as a 10/100/10000Base TX port or as a socket for an SFP module.

3. Module: Provide minimum two (2) SFP 1000BaseLX/LH modules with each switch. All SFP modules shall be the 1000BASE-LX/LH Long Haul module. Refer to drawings for required quantity of SFP modules to interconnect fiber cabling to switch.

4. Accessories: Provide a two year support contract with the manufacturer, to begin from the time that the system is commissioned and turned over to the Owner.

5. Manufacturer: Cisco Catalyst Cisco C9300-24T, no equal. Furnish and install module to support four (4) 1GB SFP uplink ports with each switch.

6. For each switch having “ESWA” or “ESWB” in its tag name, as shown on the drawings, furnish and install two (2) stacking cables.

7. For each switch having “ESWA” in its tag name, as shown on the drawings, furnish and install two (2) Stack cables, of sufficient length, to interconnect one end of each cable to Stack ports on the switch and the other end of the cable to the Stack port of the same type Ethernet switch in the same control panel but having “ESWB” in its tag name.

G. Type 2 Ethernet Switch:

1. Power Input: 120 volts A.C., 60 Hz. Unit shall be equipped with its own power supply.

2. Port Quantity and Type: 48 10/100/1000Base TX ports, 4 of which are dual purpose ports which the user may elect to use as a 10/100/10000Base TX port or as a socket for an SFP module.

3. Module: Provide minimum SFP 1000BaseLX/LH modules with each switch, as indicated on drawings. All SFP modules shall be the 1000BASE-LX/LH Long Haul module. Refer to drawings for required quantity of SFP modules to interconnect fiber cabling to switch.

4. Accessories: Provide a two year support contract with the manufacturer, to begin from the time that the system is commissioned and turned over to the Owner.

5. Manufacturer: Cisco Catalyst Cisco C9300-48T, no equal. Furnish and install module to support four (4) 1GB SFP uplink ports with each switch.

H. Ethernet Switch Accessories:

1. Furnish and install mounting brackets and hardware as required to install each Ethernet Switch according to manufacturer's instructions and requirements.

2. Furnish and install all necessary cables, connectors, and terminators as required for a complete and functional installation.

2.06 ETHERNET COPPER CABLES AND CONNECTORS AND HARDWARE GENERAL SPECIFICATIONS REQUIREMENTS

A. Provide and install copper cables, connectors, and patch cords for the Distributed Control System DCS. The ICS shall schematically design the routing and specify component make and model. The components herein shall be provided as minimum for bidding purposes.

B. Ethernet Copper Connectors: All copper Ethernet cables shall have a Category 6A boot type RJ-45 connector.

C. The installed Ethernet copper media system (including cable, data outlets, connectors, patch cords, patch panels, etc.) shall at minimum meet the TIA/EIA-568-C.2-10 Category 6A standards.

D. Ethernet Copper Patch Cords:

1. The Ethernet Copper Patch Cord shall be used to connect a communication device with a patch panel or Ethernet Copper Data Outlet. The Ethernet Copper Patch Cord shall also be used to connect devices directly to one another. At minimum, furnish and install copper patch cords for all Ethernet cabling between devices or between device and patch panel within the same cabinet. Refer to PLANS for required interconnections.

2. Each patch cord connector end shall be RJ-45 and shall be the Boot type connector. The connectors at each end shall be preinstalled by the Ethernet patch cord manufacturer.

3. The Patch Cord shall be unshielded twisted pair and shall be rated Category 6A.

4. The Ethernet copper cable outer jacket shall be Blue.

E. Copper Ethernet Data Communication Cabling:

1. Copper Ethernet Communication Cabling shall be used to interconnect copper patch panels with each other, or to interconnect Ethernet data outlets to copper patch panels.

2. The copper Ethernet cabling shall be unshielded, twisted pair, rated Category 6A cabling.

3. Agency Compliance: TIA/EIA-568-C.2, TIA/EIA-568-C.2-10 Category 6A, IEEE 802.3an 10GBASE-T Ethernet, UL Listed

4. Number of Pairs: Four

5. Wire: #23 AWG Bare Copper

6. Type of Conductors: solid copper conductors, twisted

7. Individual Conductor Insulation: minimum 300 volt polyolefin

8. Individual Conductor Insulation Color: White/Blue Stripe, Blue, White/Orange Stripe, Orange, White/Green Stripe, Green, White/Brown Stripe, Brown

9. Overall Jacket: PVC, include ripcord

10. Overall Jacket Color: Blue

11. Manufacturer: Belden 10GX32, or approved equal

F. Ethernet Copper Patch Panels

1. General Requirements for each patch panel:

a. Approvals: Meet or exceed requirements for Category 6A per TIA/EIA-568-C.2-10.

b. In addition to the device/wire tagging requirements described in Section 17200, provide additional labels as described below.

1) Overall Connector Panel Labels: Printed on the patch panel case by the Manufacturer. Provide unique, alphanumeric designation.

2) Connector Panel Adapter Port Label: Each adapter port on each Connector Panel shall have clearly labeled, printed, alphanumeric designation that is unique to that Connector Panel port and printed by the patch panel manufacturer.

3) Terminate copper cabling to patch panel in accordance to TIA/EIA-568-C.2-10 standards

4) Label each port of each patch panel. Furnish and install TTP Continuous polyester thermal transfer label as manufactured by Tyco, with ribbon and printer by label manufacturer. Label shall be white with black lettering of minimum height ¼".

c. Each patch panel shall be accompanied with a typed patch panel schedule with the following columns: Adapter ID, Cable Side, User Side, described as follows:

1) adapter ID: The adapter ID shall be of the form XX-YY, where:

a) XX is the Connector Panel identifier shown by the panel manufacturer

b) YY shall represent the adapter number within the Connector Panel.

2) Cable Side:

a) Indicate the source of the cable. Use the "patch panel tag"-XX-YY designation where applicable.

3) User Side:

a) Indicates the device (PLC, patch panel, etc.) connected to the adapter.

4) A Hard Copy print out of each Patch Panel Schedule shall be provided to the OWNER and ENGINEER. A soft copy on CD-R media of the patch panel schedule shall also be provided to the OWNER and ENGINEER.

5) Employ consistent and uniform application of identifier and adapter numbering assignment to Ethernet Copper cables along the entire span and route of each copper cable.

2. Each Type 1 Copper Patch Panel shall be as follows:

   a. Construction: Metal, primed and painted with manufacturer's standard black finish.

   b. Quantity of Ports: minimum 48. Should quantity of cable terminated to a patch panel exceed the port count of patch panel, furnish and install additional patch panels with 48 ports to accommodate all Ethernet cables (one patch panel port per cable) with an additional 12 spare/unused ports ready for future Ethernet cable terminations.

   c. Miscellaneous: Color coded front port labeling.

   d. Mounting: 19" rack mountable. Mount on 19" rack, with all necessary brackets and hardware. Refer to the PLANS.

   e. Manufacturer: Siemon, Panduit, Hubbell, CommScope, or approved equal.

3. Each Type 2 Copper Patch Panel shall be as follows:

   a. Construction: Metal, primed and painted with manufacturer's standard black finish.

   b. Quantity of Ports: minimum 24.

   c. Miscellaneous: Color coded front port labeling.

   d. Mounting: 19" rack mountable. Mount on 19" rack, with all necessary brackets and hardware. Refer to the PLANS.

   e. Manufacturer: Siemon, Panduit, Hubbell, CommScope, or approved equal .

4. Each Type 3 Copper Patch Panel shall be as follows:

   a. Construction: Metal, primed and painted with manufacturer's standard black finish.

   b. Quantity of Ports: 12.

   c. Miscellaneous: Color coded front port labeling

   d. Mounting: Mount on the backplane of the control cabinet. Provide mounting brackets and all related mounting hardware to facilitate mounting the patch panel on the backplane. Refer to the PLANS.

   e. Manufacturer: Siemon, Panduit, Hubbell, CommScope, or approved equal.

G. Cabinet Door Mount Data Jack

1. An RJ-45 data jack shall be mounted on the control cabinet door, as indicated on drawings, for owner access to communication network.

2. The cabinet door mount data jack shall be waterproof CAT6 RJ45 Panel Mount Jack, with cover, model RJ45-6WTP-CS-JCK, as manufactured by NTI.

H. Protective Relay and Power Monitoring Unit (PMU) Ethernet Cable Terminations

1. Contractor shall be aware that for each Protective/management Relay and Power Monitoring Unit (PMU), the electrical gear vendor is to furnish and install a patch panel dedicated for Ethernet cable termination to the respective Protective/management Relay or PMU. Although these patch panels may not be shown on the PLANS, contractor shall terminate all Ethernet cabling either to the patch panel dedicated for Protective/management Relay and PMU, or directly to the Protective/management Relay and PMU Ethernet port, in accordance to the preference of the Owner. Prior to installing Ethernet cabling, Contractor shall coordinate with Owner whether the patch panel is used to connect to end device or the patch panel is bypassed and Ethernet data highway (serial communication) cabling connected directly to each Power Metering Unit (PMU) and Protective/management Relay Ethernet port with the patch panel spared out for future use.

2.07 FIBER-OPTIC CABLES AND CONNECTORS AND HARDWARE GENERAL SPECIFICATIONS REQUIREMENTS

A. General: Provide and install fiber-optic cables, connectors, panels, cords, and enclosures for the Distributed Control System DCS. The ICS shall schematically design the routing and specify component make and model. The components specified herein shall be provided as minimum for bidding purposes.

B. Each fiber cable, as depicted on the drawings, represents a minimum of two (2) fiber strands. A loose tube fiber cable, as depicted on the drawings, represents the quantity of fiber strands equal to the loose tube fiber strand count as specified in this section of the specifications.

C. Fiber-Optic Cables:

1. Multiple types of fiber optic cable are required for this project as hereinafter specified. Unless specifically shown otherwise on the PLANS, all fiber optic cable shall be Type 1.

2. Type 1 Fiber Optic Cable:

a. Cable shall be Communication System Data Highway “DH” Fiber-Optic Cable. Each link external to/outside the respective Building/Room containing the Main Control Panels MCPs and the PLC Cabinets shall consist of loose tube fiber-optic cables (one cable for primary data highway communications, and another for secondary/backup data communication highway DH).

b. Cable shall consist of 72 strands of Single Mode fiber.

3. Type 2 Fiber Optic Cable:

a. Cable shall be Security System Data Highway cable as well as Telephone System Data Highway cable. Each link external to the respective Building/Room containing the Security System Control Panels and the Telephone System Control Panels shall consist of loose tube fiber-optic cables as shown on the PLANS.

b. Hybrid Multi Mode and Single Mode fiber type.

c. Cable shall consist of 18 strands of Single Mode fiber and 18 strands of Multi Mode fiber.

4. Type 3 Fiber Optic Cable:

a. Cable shall be Inter-Relay Communication Fiber Optic cable. The cable shall be loose tube fiber-optic cable.

b. Single Mode fiber type.

c. Cable shall consist of 12 strands of Single-Mode fiber.

5. General Requirements for all types of Fiber Optic Cables:

a. All fiber optic cable shall be Loose tube fiber cable

b. Mechanical stress present in the cable shall not be transmitted to the optical fibers. The fiber-optic cable shall be of loose tube construction allowing for thermal expansions and free movement of the fiber within the protective container.

c. All protective coverings in any single length of cable shall be continuous and be of the same material. The protective coverings shall be free from holes, splices, blisters, and other imperfections.

d. A flooding compound shall be applied into the interior of the fiber buffer tubes.

e. Strength members shall be an integral part of the cable construction. The combined strength of all the strength members shall be sufficient to support the stress of installation and to protect the cable in service.

f. The outer cable jacket shall be made of polyethylene (PE), except for the fiber that is run inside a building.

g. The Fiber Optic cable shall be lightning resistant.

h. The Fiber Optic cable shall be fully water blocked.

i. The fiber optic cable shall be the ALTOS loose tube type Fiber-Optic cable as manufactured by Corning Cable Systems LLC.

6. Each fiber optic cable shall be routed in a conduit that is dedicated only to that cable, and shall contain no other cable, unless explicitly noted in the drawings.

7. Optical fiber shall be coated with a suitable material to preserve the intrinsic strength of the glass. Fiber shall be protected by a protective tube, a jacketed strength member, and an exterior jacket.

8. Fibers that are multimode shall be graded index, solid glass waveguides with the following characteristics:

a. Nominal core diameter: 62.5 microns.

b. Outside clad diameter: 125 microns.

c. Minimum ellipicity: 2.0 percent.

d. Minimum Numerical Aperture (NA): 0.275.

e. Maximum attenuation (850 nm): 2.7 db/Km.

f. Minimum bandwidth (850 nm): 800 MHz/Km.

g. Maximum attenuation (1300 nm): 1.0 db/Km.

h. Minimum bandwidth (1300 nm): 800 MHz/Km.

9. Fibers that are single-mode shall be solid glass waveguides with the following characteristics:

a. Nominal core diameter: 8.3 microns.

b. Outside clad diameter: 125 microns.

c. Maximum attenuation (1310 nm): 0.5 db/Km.

d. Maximum attenuation (1550 nm): 0.4 db/Km.

10. Glass cladding shall be nominally concentric with the fiber core.

11. Each fiber shall be continuous with no factory splices.

D. Fiber-Optic Cable Terminations:

1. All fibers in all loose tube, fiber-optic cable ends shall be “fanned-out’ using a Buffer Tube Fan-Out Kit for the respective cable to allow direct connectorization of the fiber-optic cable. Thereafter, all fibers shall be attached to a connector, of the respective type for that patch panel adapter in which the fiber is installed and of the same fiber mode as that of the cable.

2. In addition to the Buffer Tube Fan-Out, the fiber optic termination shall be accompanied by a furcation Unit and Loose tube Cable End kits. The Loose Tube Cable End terminates the cable jacket and aids in cable water blocking, as well as buffer tube strain relief. Furnish and install single mode kits and multi-mode kits corresponding to the type of fiber optic cable terminated.

3. Provide a minimum 20.0-foot coil of spare fiber in each manhole throughout the cable length as well as at each patch panel.

4. Do not splice or terminate Fiber-Optic cable in underground electrical manholes and/or handholes. Also do not splice Fiber-Optic cables in any location other than Main Instrument Control Panels, PLC cabinets, and or Patch panels located in indoor climate controlled environment.

5. All fiber optic cables shall be tested for performance and loss after termination and installation to verify that at least a 4dB power safety margin is obtained between all transmitters and receivers. Test data for each fiber and safety margin calculations for each fiber path shall be provided to the Owner and Engineer after installation to verify conformance with this specification.

E. Fiber-Optic Connectors:

1. The fiber-optic device and the fiber cable end shall use the same type connectors.

2. All fiber strands associated with a Loose tube fiber cable shall be have an SC single mode connector at both ends of the strand.

3. An “SC-Duplex” connector is two (2) SC connectors abutted next to each other. Hence, a single “SC-Duplex” connector shall carry two fibers. Similarly, a single “SC-Duplex” adapter shall accept two fibers.

4. All outdoor Fiber Optic Cable shall be connectorized, at each end of the cable, to a patch panel located inside the building to which the cable is routed.

5. All fiber strands at both ends of each Fiber strand of a Fiber Optic Cable shall be terminated with a single mode SC connector, where two such connectors are joined together to form a single mode “SC-Duplex” Connector. Where fiber strand terminates directly to a fiber/optic communication device (e.g., security camera device), connector type shall be the type as required to mate with connector(s) on device.

6. Use fusion splice-on type connectors, except for those patch cords which are to be preconnectorized by the manufacturer. The connector shall be factory pre-polished connector and shall have a factory terminated pre-cleaved fiber strand pigtail that is suitable for machine aligned fusion splicing. The connector shall have a ceramic ultra PC polish Zirconia ferrule, color coded buffer, cleave protector, splice protection boot, and dust protection cap. Connectors shall be manufactured by “FIS Cheetah Splice-On Connector”, or approved equal. The connector shall conform to the following:

   a. Single-mode insertion loss (typical/maximum): 0.2db/0.3db. Multi-mode insertion loss (typical/maximum): 0.4db/0.5db.

   b. The Insertion loss is the db loss across two (2) connectors, of the same type, which are mated with each other using a fiber optic adapter of that same type

   c. Durability: < 0.2 db per 500 reconnects.

   d. All connectors shall have a ceramic zirocnia ferrule and shall be Ultra PC polished.

F. Fiber-Optic Patch Panels:

1. Fiber Optic Patch Panels designated as Type 1 on the PLANS shall be as follows:

   a. The patch panel shall be 19” rack mountable, with necessary brackets.

   b. The patch panel shall be capable of accepting up to 12 connector panels

   c. Provide and install six (6) connector panels, each with six (6) SC-Duplex single mode adapters of ceramic type

   d. Provide and install three (6) blank connector panels to cover unused patch panel slots

   e. The patch panel shall be the CCH-04U, as manufactured by Corning Cable Systems LLC.

2. Fiber Optic Patch Panels designated as Type 2 on the PLANS shall be as follows:

   a. The patch panel shall be 19” rack mountable, with necessary brackets.

   b. The patch panel shall be capable of accepting up to 6 connector panels

c. Provide and install three (3) connector panels, each with six (6) SC-Duplex single mode adapters of ceramic type

d. Provide and install three (3) blank connector panels to cover unused patch panel slots

e. The patch panel shall be the CCH-03U, as manufactured by Corning Cable Systems LLC.

3. Each port on a fiber optic patch panel, as depicted on the drawings, represents an interconnection to a minimum of two (2) fiber strands. Those ports depicted on the drawings connected to a loose tube fiber cable represents an interconnection to a minimum of the number of fiber strands within the loose tube fiber optic cable, in accordance to the loose tube fiber strand count as specified in this section of the specifications.

4. No fiber shall be permanently attached/glued/cured/spliced on a patch panel. All Fiber Optic Cables shall be attached to connectors that are then manually inserted into adapters on the patch panel. The fiber optic may be attached by a means that is removable in the future, e.g., wire ties.

5. All Connector Panels in each Patch Panel shall only consist of the single-mode, ceramic adapters unless where multi mode fiber strands are terminated to the fiber patch panel or specifically noted otherwise on the PLANS. For multi-mode fiber strands terminated to the patch panel, the Connector Panels shall be multi-mode, ceramic adapters.

6. The Fiber-optic patch panels shall be enclosed in NEMA-12 lockable enclosures for indoor installation, and NEMA-4x 316-stainless steel lockable enclosures for outdoor installation, or located within the respective Main Control Panels MCP's or within PLC Cabinets, as applicable.

7. Labeling:

   a. Each Patch Panel shall have a clearly labeled, printed, tag name, as specified for that patch panel in the PLANS. Label each patch panel in accordance to the guidelines provided in section 17200 of these specifications, under the subsection Instrument and Control Devices Identification.

   b. All Connector Panels on each Patch Panel shall have clearly labeled, printed, unique, alphanumeric designation. These designations shall be printed on the patch panel case by the Manufacturer.

   c. Each adapter on each Connector Panel shall have clearly labeled, printed, alphanumeric designation that is unique to that Connector Panel. These designations shall be printed on the connector panel by the Manufacturer.

8. General Requirement for all fiber optic patch panels:

   a. In addition to the tagging as required by the specifications, furnish and install a typed label affixed to the patch panel for each loose tube fiber cable connected to the patch panel. The label is to include the fiber strand count, the fiber strand type (e.g. single mode), the name of the building and control panel at which the other end of the cable is terminated, and the letters of the connector panels terminate to the loose tube cable, as an example as follows:

      A - F
      TO: Operations Building,
      “OP-CP-LPU2”,
      72 strand, Single Mode

   b. Affix the label on the front cover of the patch panel, adjacent to the connector panels connected to the respective loose tube fiber optic cable.

   c. The Typed Labels to be placed on the patch panels shall be 18mm Black on White Laminated Label Tape with adhesive back rated for outdoor and indoor use, Tze series as manufactured by Brother or equal. The typed lettering shall be Arial font, and minimum 3/8” High.

9. Each patch panel shall be accompanied with a typed patch panel schedule generated in the Microsoft Excel Spreadsheet program. This table shall be titled the same name as that given to the patch panel. This table shall have the following columns: Adapter ID, Cable Side, User Side:

   a. adapter ID: The adapter ID is a unique identification of the adapter in the patch panel. The adapter ID shall be of the form XX-YY, where XX is the Connector Panel identifier on the patch panel (for example, Corning Cable Systems LLC has letters "A" through "M" for each connector panel cutout in its 12 Connector Panel patch panel.) The YY shall represent the adapter number within the Connector Panel. For example, a six (6) Connector Panel that has a number in the range 1-6 next to each adapter

   b. The Cable Side column shall indicate the source of the fiber optic strands that are terminated at the back of that adapter. If the source of the strands is an adapter on another patch panel, then use the designation "patch panel-XX-YY", where patch panel is the label of the source patch panel, and XX-YY is the Adapter ID for the source adapter at the patch panel labeled patch panel. If the source is an equipment, such as a network switch or a PLC, then enter the unique equipment label as the item under the Cable Side column.

   c. The User Side column indicates the item that is connecting via connectors to the adapter on the front/user accessible side of the patch panel. The item to be connected may be a communication equipment or another patch panel. Label each item under the User Side column as was done for the items under the Cable Side column.

10. A Hard Copy print out of each Patch Panel Schedule shall be provided to the owner and engineer. A soft copy on 3.5" floppy disk (or CD-R) of the Excel files of each patch panel schedule shall also be provided to the owner and engineer.

11. When a fiber optic cable spans from a source Patch Panel to a destination Patch panel, for every fiber that is connected at the source patch panel to a particular Connector Panel with an identifier x and adapter with identifier y on that Connector Panel, then the other end of this fiber shall be attached to the Connector Panel with Identifier x and adapter identifier y at the destination patch panel, where x and y are variables representing the alphanumeric designations of patch panel connector panels and adapters.

G. Fiber-Optic Patch Cords:

1. Patch cords shall be utilized for indoor runs of fiber cable between a fiber-optic device and a fiber-optic patch panel, between adapters on the user side f two-patch panels, or between two fiber optic devices.

2. Any fiber patch cord shall satisfy the requirements described in these specifications for fiber patch cords.

3. All fiber patch cords that are connected to single-mode devices/patch panel adapters shall be 8.3/125 micron single-mode cables and single-mode connectors and shall possess the attenuation and bandwidth parameters as specified for fiber-optic cable and connectors as described in these specifications and required to interconnect with device.

4. All fiber patch cords that are connected to multimode devices/patch panel adapters shall be 62.5/125 micron multimode cables and multimode connectors and shall possess the attenuation and bandwidth parameters as specified for fiber-optic cable and connectors as described in these specifications and required to interconnect with device.

5. Each fiber in each patch cord shall be placed in individual tight thermoplastic buffer tubes and protected with kevlar strength members and enclosed with a thermoplastic jacket with an outer diameter of at least 2.5mm.

6. Each patch cord shall consist of at least two (2) fibers, according to the fiber count requirements of the communication devices the cable is interconnecting.

7. Each patch cord shall be pre-connectorized with the appropriate type connector by the manufacturer

8. SC-Duplex to SC-Duplex Patch Cords shall be of type single mode and shall consist of SC-duplex connectors on both ends of the patch cord. These SC-duplex connectors shall be single mode, with ceramic zirconia ferrule and Ultra PC polish. In particular, these patch cords will be used to connect a fiber patch panel adapter to another fiber patch panel adapter as well as device with SC-duplex ports to the patch panel.

9. SC-Duplex to LC-Duplex Patch Cords shall be of type single mode and shall consist of SC-Duplex connector on one end of the patch cord and LC-Duplex with spring on the other. The SC-Duplex connectors shall be single mode, with ceramic zirconia ferrule and Ultra PC polish. The LC-Duplex connectors shall be single mode, with ceramic zirconia ferrule, with an integrally mounted spring, and Ultra PC polish. In particular, these Patch cords will be used to connect a fiber patch panel adapter to an SFP device on an Ethernet Switch.

10. LC-Duplex to LC-Duplex Patch Cords shall be of type single mode and shall consist of LC-Duplex connector on both ends of the patch cord. Each LC-Duplex connector shall be single mode, with ceramic zirconia ferrule, with an integrally mounted spring, and Ultra PC polish.

11. All fiber patch cords shall not consist of any splices of the fiber strands.

12. Fiber patch cord transmit and receive signals may only be swapped at optical devices, such as a GBIC module, or SFP module. The fiber patch cord signals shall not be swapped when the patch cord is connected from a fiber patch panel adapter to another patch panel adapter.

13. All patch cords, and all components thereof, shall be manufactured by Corning Cable Systems LLC.

14. The patch cords shall be the Zipcord cables, as manufactured by Corning Cable Systems LLC.

2.08 LAPTOP PROGRAMMING COMPUTER

A. Mother Board

1. A minimum of Intel Intel Core i7-7820HQ (Quad Core 2.90GHz, 3.90GHz Turbo, 8MB 45W, w/Intel HD Graphics 630)

2. 16GB, DDR4-2400MHz SDRAM, 1 DIMMS

B. Hard Drive (HDD)

1. Minimum 500GB Solid State Hard Drive.

2. The hard drive shall be partitioned with the NTFS file system type

C. Pointing Device and Keyboard

1. Keyboard

a. Anti-microbial keyboard with number pad and backlight feature

2. The laptop shall consist of integrated dual pointing device

a. Touchpad pointer and stick pointer

b. Multi-touch touchpad with three buttons

D. Graphics Display

1. The integrated laptop display type shall be 15.6" UltraSharp FHD(1920x1080) Wide View Anti-Glare LED-backlit, non-touch

E. Peripheral Ports

1. 1 x SD Card Reader (SD, SDHC, SDXC, supporting up to 2TB);
2. 1 x Thunderbolt ® 3
3. 4 x USB3.0 with PowerShare;
4. 1 x mDP 1.4;
5. 1 x HDMI 1.4;
6. 1 x Headphone and microphone combo jack;
7. 1 x SmartCard Reader

F. Video

1. Minimum of Nvidia Quadro M1200 w/4GB GDDR5
2. The Computer shall have a special function key that enables the video card signal to be sent to the Laptop's LCD display, the HDMI output port, or both

G. Audio

1. The laptop shall consist of a minimum of Stereo: 20-bit stereo-digital to analog and 18-bit stereo analog to digital 16 bit integrated audio card
2. Dual integrated high quality speakers

H. Communication

1. The laptop shall at minimum have the following communication devices
   a. Intel WiFi Link 8265 Card (802.11ac + Bluetooth 4.2), 2x2
   b. Integrated 10/100/1000 BASE-TX Gigabit Ethernet communication with RJ-45 port interface
2. All communication drivers for each communication device shall be installed on the laptop.

I. Battery

1. The Laptop battery shall be user accessible and replaceable
2. Minimum 91Whr long life cycle Ion Polymer battery
3. The laptop is to have a charging unit to fully charge the battery while providing full power to the laptop.
4. The charging means shall also be a means of providing power to the laptop in the event that the battery is fully discharged.

J. Software

1. Each software installed on the laptop shall be legally licensed to the owner.

2. Operating System

   a. Microsoft Windows 10 Professional, 64-bit, with service packs and media

3. Drivers and Laptop Maintenance utilities

   a. All drivers and Laptop maintenance and diagnostic utilities including battery percent charged, estimate of laptop remaining operation time when powered only by the battery source, shall be Windows 10 Professional compatible.

   b. Drivers for the following shall be installed on Windows 10 professional system are:

      1) Network Communications

      2) Audio card

      3) Video card

      4) Battery time of operation estimation and battery percent charged

      5) Laptop suspend (sleep) mode

4. Provide the media (DVD-ROM or USB) and installation guide for all software, including the operating system and all media for complete system recovery to the Laptop system state as initially provided out of the package by the Laptop manufacturer.

K. USB Flash Drives

1. Provide two (2) 128 gigabyte USB 3.0 removable Flash Drive Units.

L. Backpack Case

1. Provide Nylon Deluxe back pack case sufficiently large to house the Laptop unit

2. The case should have additional pouches/pockets for storage of cables, CD R disks, etc.

M. The Laptop shall include a five (5) year manufacturer's warranty covering parts and labor and next business day on site support as well as ProSupport and 3 Year CompleteCare Accidental Damage Protection

N. The Laptop shall be manufactured by Dell and shall be the most current version of the Dell model Precision Workstation series laptops.

2.09 TYPE 1 OPERATOR INTERFACE UNIT

A. General: The OIU shall effectively be a Graphical front end to the local PLC network and have complete read/write access to all registers of the local PLC network to which the OIU is connected.

1. Communication:

   a. The OIU shall utilize Ethernet communication protocols to communicate to other peripheral devices, including PLC's, as shown in the contract drawings.

   b. The ICS shall provide the necessary cabling for communicating with the OIU for programming and configuration purposes with a personal computer. The program cabling shall be USB and minimum of 12 feet in length.

   c. The ICS shall install the necessary cabling, connectors, and termination for communication between the OIU Ethernet interface and the Ethernet network.

2. Software:

   a. Operating System: Magelis Operating system, with latest service Pack, preinstalled by the OIU manufacturer.

   b. Software: Vijeo Designer run time software, preinstalled by the OIU manufacturer.

   c. All additional necessary software, software drivers, etc. complete will all licenses, as necessary for the proper operation of the OIU.

3. Mounting:

   a. Mount in control panel door as shown on the Drawings. All communication ports shall be accessible with OIU installed in the control panel.

   b. Provide mounting hardware as required and install OIU according to manufacturer's instructions and requirements. Provide trim accessories to seal the gap between the OIU and control panel door.

4. Accessories:

   a. 1 Gigabyte secure digital (SD) card, manufactured by the OIU manufacturer.

   b. All necessary cables, connectors, and terminators. Minimum cable length shall be 12 feet

B. Display Module:

1. Type: Flat Color Active Matrix (TFT) LCD display type, with touch screen capability

2. Size: 15" diagonal

3. Minimum Resolution: 1024 x 768 pixels,

4. Colors: 16,000,000 colors

5. Power Input: 24 volts DC.
6. Communication Ports:
    a. One (1) USB 2.0 Type A port,
    b. One (1) USB 2.0 Mini-B port
7. Physical Environment:
    a. Ambient Air Temperature: +32° to +140° Fahrenheit
    b. Ambient Air Humidity: 10% to 90% Relative Humidity Non-condensing
    c. Free of corrosive gases
8. Cooling Method: Natural air circulation
9. Enclosure: NEMA 4X rated
10. Manufacturer: Schneider Electric Magelis GTU HMIDT732, No Equal.

C. Box Module:
1. Power Input: 24 volts DC.
2. Memory:
    a. System Card: SD Card 1 GB
    b. Internal Memory: 256 MB RAM
    c. Backup Memory: 512 kB NVRAM
3. Communication Ports:
    a. Two (2) RJ-45 Ethernet ports,
    b. Two (2) USB 2.0 Type A ports,
    c. One (1) USB 2.0 Mini-B port,
    d. One (1) RJ-45 RS-485 serial port,
    e. One (1) 9 pin RS-232/422/485 serial port,
    f. Two (2) SD card slots [one (1) system and one (1) storage]
4. Communication Protocol: Ethernet, Modbus TCP/IP
5. Output Interface:

a. One (1) 300 mW speaker output,

b. One (1) 24 VDC auxiliary alarm output

6. Physical Environment:

a. Ambient Air Temperature: +32° to +140° Fahrenheit

b. Ambient Air Humidity: 10% to 90% Relative Humidity Non-condensing

c. Free of corrosive gases

7. Cooling Method: Natural air circulation

8. Manufacturer: Schneider Electric Magelis GTU HMIG3U, No Equal.

2.10 TYPE 2 OPERATOR INTERFACE UNIT

A. General: The OIU shall effectively be a Graphical front end to the local PLC network and have complete read/write access to all registers of the local PLC network to which the OIU is connected.

B. Display screen:

1. Type: Flat Color Active Matrix (TFT) LED display type, with touch screen capability

2. Size: 19” diagonal

3. Minimum Resolution: 1280 x 1024 pixels

4. Colors: 32 bit color

5. Accessories:

a. Pop up window for numeric keypad and alphanumeric keypad displays

b. Touch sensitive protective film harsh environment coating

C. Hardware:

1. Communication Ports:

a. Two (2) RS-232 ports

b. Four (4) USB 3.0 ports

c. Three (3) 10/100/1000 Base Tx Ethernet port. Ports may be obtained by use of Ethernet module installed in PCI slot

2. Enclosure: Stainless steel, NEMA 4 rated

3. Power Input: 24 volts DC

4. Hard Drive: Minimum of 256 GB solid state disk

5. Processor: Intel i7 processor with minimum 3 GHz clock speed

6. Memory: 8 GB RAM, at minimum.

D. Communication:

1. The OIU shall utilize Ethernet communication protocols to communicate to other peripheral devices, including PLC's, as shown in the contract drawings.

2. The ICS shall install the necessary cabling, connectors, and termination for communication between the OIU Ethernet interface and the Ethernet network.

E. Software:

1. Operating System: Windows 10 Professional, 64 bit Operating system, with latest service Pack, preinstalled by the OIU manufacturer.

2. Application Software: Furnish one (1) GE Proficy HMI SCADA iFix latest software versions, client, run time license with USB key. The iFix software shall be registered in the name of the owner. SCADA Software will be installed by Owner.

3. All additional necessary software, software drivers, etc. complete with all licenses, as necessary for the proper operation of the OIU.

F. Keyboard:

1. Sealed to Nema 4X standards, heavy duty industrial type keyboard suitable for harsh environment.

2. 113-key functionality (includes a separate numeric keypad and 20 function keys), Integrated Button Pointer.

3. Key Material - Industrial silicone rubber

4. Key Travel: 0.098", 0.45 lb. nominal actuation force, 10 million cycle life

5. Three year warranty

6. Full-Travel Wall Mount Keyboard with Button Pointer Model KB-R2-WMT-BLK-4-USB as manufactured by Hope Industrial.

7. Mount Keyboard on front of panel door below OIU using keyboard vendor provided mounting hardware and template. Mount keyboard such that the typing surface of the keyboard is 38" above finished floor (floor on which user is standing to face OIU), inclusive of housekeeping concrete pad height. Mount keyboard such that it is horizontally centered on the door.

G. Mounting:

1. VESA mount OIU on face of control panel at door shown on the Drawings. All communication ports shall be accessible with OIU installed on the control panel.

2. Provide mounting brackets and hardware as required and install OIU and all accessories according to manufacturer's instructions and requirements.

H. Accessories:

1. All necessary cables, connectors, and terminators. Minimum cable length shall be 12 feet

2. VESA mount Fixed Low-Profile Flat-Panel Mount bracket. Coordinate bracket with OIU mounting requirements. Bracket shall be model PRF as manufactured by Premier Mount, or approved equal.

3. Keyboard Bracket.

4. Panel mountable, gasketed, Nema 4X rated split cable gland kit for all cables connecting to OIU through control panel door. Split cable gland kit shall be as manufactured by Icotek Kel-ER, or approved equal.

5. Nema 4X gasketed cable grommets for final cable connection to OIU per the OIU manufacturer's recommendations.

I. Manufacturer: Noax Technologies Steel Series S19 complete with specified accessories, No Equal.

PART 3 - EXECUTION

3.01 GENERAL INSTALLATION

A. The ICS shall furnish labor, materials, equipment, and incidentals required to install the system in accordance with specification section 17100 and 17600.

B. The ICS shall be responsible for ensuring that field wiring for power and signal circuits is correct and wired in accordance with best industry practice. Also, the ICS shall be responsible for providing all necessary system grounding to insure a satisfactory functioning installation.

3.02 FIBER-OPTIC SYSTEM - SOURCE QUALITY CONTROL

A. Fiber Optic Splice-on Connector Termination:

1. The specified splice-on connectors shall be terminated using a fusion splicer and splicing oven with fiber holders to ensure the fiber cables are machine aligned prior to splicing. The fusion splicer shall be the Fujikura 12S Fusion Splicer, or approved equal. The connector oven shall be the FIS Cheetah Splice-On Connector Oven, or approved equal. Splicer and oven shall be compatible with the splice-on connectors. The loss of the

fusion splice shall be no greater than 0.1 dB. Contractor shall provide a submittal for the loss of each fusion splice. The submittal shall be a listing of each fiber optic cable, with cable tag, cable end designation, and strand number along with the strand end's fusion splice loss in dB.

B. Fiber Optic On-Site Testing:

1. General: The ICS shall provide all equipment, instrumentation, and supplies necessary to perform all testing. The Owner and the Engineer shall have the option to witness and participate actively in the On-Site tests performed by the ICS firm.

2. Pretesting: Prior to the physical placement of the fiber optic cable, each fiber shall be tested on-Site, while on the spool, with an Optical-Time-Domain Reflectometer "OTDR" at wavelength of 1310 nm and 1550 nm for single-mode cable and 850nm and 1300nm for multimode cable. The OTDR test shall ensure that the fibers conform to the manufacturers' attenuation specifications and that no damage occurred to the cable during shipping. Hard copy plots of the tests shall be provided to the Engineer prior to approval for the placement to proceed.

3. Post-Testing:

   a. The OTDR used for single-mode fiber cable testing shall be an OTDR designed for single-mode cable testing and shall consist of a laser light source used for transmitting test signals through the fiber under test.

   b. An OTDR unit which is designed for both multimode and single-mode fiber testing may be used. The unit must be configured for single-mode cables when testing single-mode cables.

   c. OTDR tests shall be done on all installed fibers (both used and unused fibers) after connectorization and will be preformed from both ends of the cable. These tests must document the cable tested, fiber number, total length of fiber, attenuation of the fiber, and the power loss (in dB) across the length of fiber cable tested. The tests shall be performed at wavelength of 1310 nm and 1550nm for single-mode cable. A permanent hard copy of all OTDR traces shall be provided to the owner and engineer.

   d. All OTDR test results shall be printed such that the insertion loss across the connectors can be determined from the traces, as well as loss across the cable. The traces shall be displayed on a trend chart with size 7" long and 5" high. The trace shown should be zoomed/scaled so that it spans the area of the displayed chart, and the vertically and horizontal axis labels adjusted accordingly. In addition, the results shall show the individual numerical dB loss values of the loss across each connector, each splice, and each fiber cable.

   e. Contractor shall use launch cables and tail cords (receive cables) when performing testing with the OTDR. The length of the launch cable shall be at least 500 feet so as to allow a clear indication of the insertion loss of the connectors on the patch panels on both sides of the cable tested.

   f. Fiber end-to-end attenuation testing

1) Fiber end-to-end attenuation testing shall be performed on all installed fibers (both used and unused fibers) after connectorization from both ends of the cable.

2) These tests shall utilize a stabilized light source and optical power meter. The attenuation tests shall be performed at wavelengths of 1310 nm and 1550 nm for single-mode cable. Documented results to be provided shall include the cables tested, fiber number, direction of tests, wavelength, the power loss (in dB) across the length of fiber cables tested, and reference power reading.

g. Fiber device-to-device attenuation testing

1) This testing shall be performed after all necessary patch fiber patch cords have been installed in the system.

2) This test shall be performed on all renovated fiber optic links between fiber optic devices. The test shall be conducted only after all necessary patch cords to be used in the final system to create the link between devices are properly installed. The tests shall be performed from both ends of the link. The test should include all installed patch cords in the link, including the end patch cords that are to connect to the switches themselves.

3) These tests shall utilize a stabilized light source and optical power meter as well as OTDR. The attenuation tests shall be performed at wavelengths of 1310 nm and 1550 nm for Single Mode cable and 850nm and 1300nm for Multi-Mode cable. Documented results to be provided shall include the cables tested, fiber number, direction of tests, wavelength, the power loss (in dB) across the length of fiber cables tested, and reference power reading and OTDR results, as identified in these specifications.

C. Fiber Optic Splicing:

1. The fiber optic cableplant as designed by the ICS shall ensure a minimum of splices and only in locations permitted by these specifications. Where splices are necessary, the optical fibers shall be fusion spliced with a splice loss not to exceed 0.2-dB. All splices shall be tested with an Optical Time Domain Reflectometer (OTDR) bidirectionally to verify splice loss at the time of splicing. Any splices not conforming to these specifications shall be redone to meet the specifications.

2. During the splicing operations, means shall be provided to protect the unspliced portions of the cable from the intrusion of moisture and other foreign matter.

3. Furnish and install Tyco Electronics FOSC 400 splice enclosure, for a water tight and air tight seal of the splice, per manufacturer's recommendations and requirements. Furnish and install all required splice trays to accommodate all splices. Furnish and install mounting hardware for the mounting of the splice enclosure. All hardware shall be 316 stainless steel. Mount splice enclosure so as not to place any stress on the fiber optic cables.

4. All required splices not identified by submittal shall be brought to the attention of the Owner and Engineer for approval prior to implementation.

3.03 COPPER ETHERNET CABLE SYSTEM TESTING

A. After installation of Copper Ethernet Cable System, ICS shall perform testing of the cable system to assure compliance of the installed system with the TIA/EIA-568-C.2-10 Category 6A requirements. Testing shall be performed for all installed copper cable systems, including used and unused links, from end-to-end, including all data outlets, connectors, patch panels, patch cords, etc

B. Copper Ethernet Cable System Test reports shall be submitted to the engineer and owner for review and approval. The test report shall document, for each copper data link, description of the link and components therein, the testing method used, test results, and demonstrate compliance with TIA/EIA-568-C.2-10 of the link. If any installed link does not meet the TIA/EIA-568-C.2-10 Category 6A requirements, ICS shall repair/modify link to assure it is compliant with TIA/EIA-568-C.2-10 Category 6A standard at no additional cost to the Owner.

3.04 TESTS (GENERAL)

Refer to Section 17100.

3.05 INITIAL ON-SITE DEMONSTRATION TESTS "ISDT"

A. Programmable Logic Controllers PLCs:

1. Test all loop-specific functions and demonstrate all I/O Points.

2. Test all non-loop-specific functions including, but not limited to, the following:

   a. Failure Mode and Backup Procedures: Power failure, auto restart, retentive outputs.

   b. Data Highway DH Dual Primary and Backup communications switching.

   c. Communication with existing PCs.

3. Refer to Section 17100.

3.06 OPERATIONAL READINESS TESTS (ORT)

Refer to Section 17100.

3.07 PERFORMANCE ACCEPTANCE TESTS (PAT)

Refer to Section 17100.

3.08 RELIABILITY ACCEPTANCE TESTS (RAT)

Refer to Section 17100.

PART 4 - PLCS TRAINING

4.01 GENERAL TRAINING REQUIREMENTS

A. Prior to performing training, ICS shall coordinate the training periods with OWNER personnel, and shall submit a training schedule for each training course to be provided. Such training schedule shall be submitted not less than 4 weeks prior to the time that the associated training is to be provided. Upon approval of the training schedule by the OWNER, contractor may then commence training per the OWNER approved training schedule.

B. ICS shall submit all course description and outlines for all proposed training for review by the OWNER and approved by the OWNER prior to commencing the training outlined for the course.

C. A certified representative of the hardware and/or software Manufacturer, as applicable, shall be the instructor of the respective training course. Instructor shall have a minimum one (1) year of experience in the training course material. For each proposed training course, submit instructor qualifications for review and approval by OWNER.

D. All courses shall consist of hands on computer training with one person per one computer and all necessary training software per computer provided by instructor. For PLC training, in addition to the computer, a hardwired training PLC system shall be provided per student. Each course shall also include printed, hardcopy manuals and course material provided by the instructor for the count of personnel identified for the course. All printed course material shall be provided to and kept by each student in the course. At the completion of the course, each student shall be provided a hard copy printed certificate of course completion, with the certificate at minimum including printed the student's name, the name of the course, hours of training received, and the date of course completion.

4.02 HARDWARE MAINTENANCE TRAINING

A. Provide a minimum of one (1) week, 40 consecutive normal working hours, of onsite hardware training for a total of ten of the Owner's instrument technicians in the maintenance of the PLCS hardware. This training shall be provided at an Owner/Engineer approved training center in Austin, Texas. Training shall include, but not be limited to:

1. Training shall include demonstration by an instructor as well as hands on training for each student in the class

2. Standard hardware features of the PLCs.

3. Specific training for the actual hardware configuration provided.

4. Test, adjustment, and calibration procedures.

5. Troubleshooting, component removal and replacement, and periodic maintenance.

4.03 SOFTWARE MAINTENANCE TRAINING

A. Training:

1. Length and duration of the course shall be as required for the standard course duration offered by the manufacturer's representative.

2. All software training shall be private training session and shall be provided for at least ten (10) of the Owners personnel.

3. Training shall include demonstration by an instructor as well as hands on training for each student in the class

4. Length and duration of the course shall be as required for the standard course duration offered by the manufacturer's representative.

5. Include training for the following software (minimum 40 hours training duration for each item):

   a. Modicon Unity Pro XL, for PLC's

   b. GE Proficy iFix Software (for OIU)

   c. Cisco Ethernet switches/routers

6. This training shall be provided at an Owner/Engineer approved training center in Austin, Texas. Training shall commence and shall be completed within the time period depicted by the Owner/Engineer. Reflect this training time period on the project construction schedule. Software training shall not be conducted at the project site or any other City of Austin owned and operated facility. Software training shall be based on the most recent software-programming environment available for the respective equipment.

7. Software training shall be designed for students having the equivalent of a one-semester class on personal computers, but no professional programmable controller programming experience, OIU programming experience, or Ethernet switch configuration experience. Software shall provide instruction and experience such that these students shall be able to:

   a. Operate the equipment (PLC, OIU, Ethernet Switch) on a day-to-day basis.

   b. Make programming changes.

   c. Assist the hardware maintenance technicians in diagnosing problems with the equipment (PLC, OIU, Ethernet Switch).

8. For the PLC Unity Pro XL training, provide at minimum the following courses: Schneider course PLCUTY13 (Unity Pro Programming Level 1), and Schneider course PLCUTY23 (Unity Pro Programming Level 2). The training shall include at minimum:

   a. System Overview: Basic system design, configuration, functions, maintenance, and operation.

b. System Hardware: Specific hardware provided.

c. General Programming and Documentation: How to program a PLC and how to document the program.

d. Diagnostic and Troubleshooting: Capabilities, usage, and interpretation of results.

9. For the OIU software training, the courses shall at minimum be "Proficy HMI/SCADA iFix Fundamentals" and "Proficy HMI/SCADA iFix Advanced" training provided directly by GE. The training shall also be for Schneider Magelis Vijeo Designer software training provided directly by Schneider. The training shall include at minimum the following for each type of OIU software:

   a. Overview of the graphics primitive symbols and how to animate them with data.

   b. Setting up templates, including alarm templates and process graphics screen templates

   c. Overview of the communication protocols available and how to configure them.

   d. Configuration of the OIU setup parameters, such as startup screen, the unit address, date and time, and synchronization with the PLC.

   e. Configuration of alarms

   f. How to configure the programming computer for interface with and programming of OIU.

   g. How to add and modify polled devices over Ethernet to the software configuration of the current OIU program

   h. Adding graphical push buttons, slide bars, etc. on the OIU graphics screen and how to animate them for data input from the OIU to the PLC

   i. Setup of OIU security

   j. Setup and utility features available from the OIU itself while it is running: such as viewing historical alarms, purging historical alarms, OIU screen saver.

   k. Diagnostics in the event of OIU failure: such as OIU hardware failure, communication failure, loss of memory.

   l. In the event of OIU program memory loss, how to restore the program and place the OIU back on line.

   m. In the event of OIU program memory loss, how to insert a backup memory card and place the OIU back on line.

10. Provide Cisco Ethernet Switch training for a minimum duration of 10 business days. The training shall be performed by New Horizons Worldwide, Inc., in Austin Texas and shall be a private training session exclusively for the personnel designated for this

project by the Owner. It should be clarified that this training class is intended for the students to have hands on knowledge to troubleshoot, configure, and maintain the installed Cisco equipment and Not necessarily to attain Cisco certification. The course training shall provide each student with each Ethernet switch whose configuration is discussed in the training session for hands on use of the Ethernet switch by each student. For the Ethernet Switch configuration provide, at least, the following training:

a. How to remotely manage/configure the Ethernet switch/router with an IBM PC compatible computer from:

    1) Serial/USB communication port

    2) terminal telnet session

    3) web browser

b. How to change the configuration settings of the switch, including its name, IP address, user passwords using commands at the command prompt via serial communication or terminal sessions, as well as graphically from a browser.

c. Overview of the Ethernet switch hardware provided.

d. Overview of Ethernet switch configuration settings, as well as guidelines and examples, configured by using commands at the command prompt via serial communication or terminal sessions, as well as graphically from a browser.

e. Provide emphasis and show actual settings for all configuration settings of the switches used in the plant, in particular those settings relating to setting of VLAN's, VLAN truncking, STP and RSTP setup.

f. Provide training on Cisco management tools that provide overview, from a web browser, of all the switches in the network, link status, and port status, as well as how to configure such a management tool, and viewing logs of system events, such as network link failures, internal diagnostic failures, modules failures, etc.

g. Provide training for upgrading the onboard software of an Ethernet switch

h. Provide training for how to store settings from the switch to a file, as well as how to store settings to a switch from a file.

i. Provide this training for both command based as well as browser-based configuration via direct connection to the switch (console port) as well as from the switch management tool.

j. Diagnostic and Troubleshooting: Capabilities, usage, and interpretation of results.

4.04 MEASUREMENT AND PAYMENT

A. No separate measurement or payment for work performed under this Section. All costs are included in the Base Bid.

END OF SECTION

ATTACHMENT "A" OF SECTION 17600
DISTRIBUTED CONTROL SYSTEM
SOUTH AUSTIN REGIONAL
WASTEWATER TREATMENT PLANT
ELECTRICAL SUBSTATION NO. 1 REPLACEMENT

SUBSTATION NO. 1

DESCRIPTION	PANEL	RACK	MODULE	PT.
AIT/1401 "HYDROGEN CONCENTRATION ANALYSIS"	SUB1-MCP-001	001	AI-01	01
TIT/1402 "ELECTRICAL EQUIPMENT SPACE AMBIENT AIR TEMPERATURE"	SUB1-MCP-001	001	AI-01	02
AIT/1403 "ELECTRICAL EQUIPMENT SPACE AMBIENT AIR HUMIDITY"	SUB1-MCP-001	001	AI-01	03
SPARE	SUB1-MCP-001	001	AI-01	04
TIT/1404 "CONTROL SPACE AMBIENT AIR TEMPERATURE"	SUB1-MCP-001	001	AI-01	05
AIT/1405 "CONTROL SPACE AMBIENT AIR HUMIDITY"	SUB1-MCP-001	001	AI-01	06
TIT/1406 "SUB1-MCP-001 INTERNAL AIR TEMPERATURE"	SUB1-MCP-001	001	AI-01	07
TIT/1407 "SUB1-MCP-001 INTERNAL AIR TEMPERATURE"	SUB1-MCP-001	001	AI-01	08
PIT/1415 "AIR CONDITIONING UNIT NO. 1 SUPPLY DUCT PRESSURE"	SUB1-MCP-001	001	AI-02	01
SPARE	SUB1-MCP-001	001	AI-02	02
Z/AVD101 "SCRUBBER NO. 1 OUTSIDE AIR DAMPER POSITION FEEDBACK"	SUB1-MCP-001	001	AI-02	03
FIT/1411 "SCRUBBER NO. 1 OUTSIDE AIR FLOW"	SUB1-MCP-001	001	AI-02	04
FIT/1411 "SCRUBBER NO. 1 OUTSIDE AIR FLOW FAIL" ALARM	SUB1-MCP-001	001	AI-02	05
TIT/1412 "SCRUBBER NO. 1 OUTSIDE AMBIENT AIR TEMPERATURE"	SUB1-MCP-001	001	AI-02	06
PDIT/1413 "SCRUBBER NO. 1 PRE-FILTER AIR PRESSURE DIFFERENTIAL"	SUB1-MCP-001	001	AI-02	07
PDIT/1414 "SCRUBBER NO. 1 FINAL-FILTER AIR PRESSURE DIFFERENTIAL"	SUB1-MCP-001	001	AI-02	08
PIT/1425 "AIR CONDITIONING UNIT NO. 2 SUPPLY DUCT PRESSURE"	SUB1-MCP-001	001	AI-03	01
SPARE	SUB1-MCP-001	001	AI-03	02
Z/AVD201 "SCRUBBER NO. 2 OUTSIDE AIR DAMPER POSITION FEEDBACK"	SUB1-MCP-001	001	AI-03	03
FIT/1421 "SCRUBBER NO. 2 OUTSIDE AIR FLOW"	SUB1-MCP-001	001	AI-03	04
FIT/1421 "SCRUBBER NO. 2 OUTSIDE AIR FLOW FAIL" ALARM	SUB1-MCP-001	001	AI-03	05
TIT/1422 "SCRUBBER NO. 2 OUTSIDE AMBIENT AIR TEMPERATURE"	SUB1-MCP-001	001	AI-03	06
PDIT/1423 "SCRUBBER NO. 2 PRE-FILTER AIR PRESSURE DIFFERENTIAL"	SUB1-MCP-001	001	AI-03	07
PDIT/1424 "SCRUBBER NO. 2 FINAL-FILTER AIR PRESSURE DIFFERENTIAL"	SUB1-MCP-001	001	AI-03	08
Z/AVD101 "SCRUBBER NO. 1 OUTSIDE AIR DAMPER POSITION SETPOINT"	SUB1-MCP-001	001	AO-01	01
SPARE	SUB1-MCP-001	001	AO-01	02
Z/AVD201 "SCRUBBER NO. 1 OUTSIDE AIR DAMPER POSITION SETPOINT"	SUB1-MCP-001	001	AO-01	03
SPARE	SUB1-MCP-001	001	AO-01	04
AC PWR FAIL/BC1 "AC POWER FAIL" ALARM	SUB1-MCP-001	001	DI-01	01

SUBSTATION NO. 1

DESCRIPTION	PANEL	RACK	MODULE	PT.
NCA/BC1 "NO CHARGE" ALARM	SUB1-MCP-001	001	DI-01	02
LVA/BC1 "DC VOLTAGE LOW" ALARM	SUB1-MCP-001	001	DI-01	03
HVA/BC1 "DC VOLTAGE HIGH" ALARM	SUB1-MCP-001	001	DI-01	04
GND POS/BC1 "POSITIVE GROUND DETECTION" ALARM	SUB1-MCP-001	001	DI-01	05
GND NEG/BC1 "NEGATIVE GROUND DETECTION" ALARM	SUB1-MCP-001	001	DI-01	06
SPARE	SUB1-MCP-001	001	DI-01	07
BKRb/ATS1N "BREAKER OPEN" STATUS	SUB1-MCP-001	001	DI-01	08
BKRa/ATS1N "BREAKER CLOSED" STATUS	SUB1-MCP-001	001	DI-01	09
SPARE	SUB1-MCP-001	001	DI-01	10
NP/ATS1 "NORMAL POWER" STATUS	SUB1-MCP-001	001	DI-01	11
EP/ATS1 "EMERGENCY POWER" STATUS	SUB1-MCP-001	001	DI-01	12
SPARE	SUB1-MCP-001	001	DI-01	13
FA/FACP "FACP FIRE ALARM" STATUS	SUB1-MCP-001	001	DI-01	14
SPARE	SUB1-MCP-001	001	DI-01	15
FAIL/SMR1 "SUBSTATION MANAGEMENT RELAY FAIL" ALARM	SUB1-MCP-001	001	DI-01	16
AC PWR FAIL/BC2 "AC POWER FAIL" ALARM	SUB1-MCP-001	001	DI-02	01
NCA/BC2 "NO CHARGE" ALARM	SUB1-MCP-001	001	DI-02	02
LVA/BC2 "DC VOLTAGE LOW" ALARM	SUB1-MCP-001	001	DI-02	03
HVA/BC2 "DC VOLTAGE HIGH" ALARM	SUB1-MCP-001	001	DI-02	04
GND POS/BC2 "POSITIVE GROUND DETECTION" ALARM	SUB1-MCP-001	001	DI-02	05
GND NEG/BC2 "NEGATIVE GROUND DETECTION" ALARM	SUB1-MCP-001	001	DI-02	06
SPARE	SUB1-MCP-001	001	DI-02	07
BKRb/ATS1E "BREAKER OPEN" STATUS	SUB1-MCP-001	001	DI-02	08
BKRa/ATS1E "BREAKER CLOSED" STATUS	SUB1-MCP-001	001	DI-02	09
SPARE	SUB1-MCP-001	001	DI-02	10
NP/ATS2 "NORMAL POWER" STATUS	SUB1-MCP-001	001	DI-02	11
EP/ATS2 "EMERGENCY POWER" STATUS	SUB1-MCP-001	001	DI-02	12
SPARE	SUB1-MCP-001	001	DI-02	13
SPARE	SUB1-MCP-001	001	DI-02	14
SPARE	SUB1-MCP-001	001	DI-02	15
SPARE	SUB1-MCP-001	001	DI-02	16
ALM/1401 "SUBSTATION NO. 1 HYDROGEN CONCENTRATION LEVEL" ALARM	SUB1-MCP-001	001	DI-03	01
FAIL/1401 "SUBSTATION NO. 1 HYDROGEN CONCENTRATION ANALYSIS FAIL" ALARM	SUB1-MCP-001	001	DI-03	02
FA/PDP1 "SPD FAIL" ALARM	SUB1-MCP-001	001	DI-03	03

SUBSTATION NO. 1

DESCRIPTION	PANEL	RACK	MODULE	PT.
FAIL/PS1 "24VDC POWER SUPPLY FAIL" ALARM	SUB1-MCP-001	001	DI-03	04
SPARE	SUB1-MCP-001	001	DI-03	05
FAILURE/INV1 "SYSTEM COMMON FAILURE" ALARM	SUB1-MCP-001	001	DI-03	06
VDC LOW/INV1 "LOW DC VOLTAGE" ALARM	SUB1-MCP-001	001	DI-03	07
SPARE	SUB1-MCP-001	001	DI-03	08
SPARE	SUB1-MCP-001	001	DI-03	09
BTH/BM1 "BATTERY TEMPERATURE HIGH" ALARM	SUB1-MCP-001	001	DI-03	10
FAIL/BM1 "SYSTEM MONITOR FAIL" ALARM	SUB1-MCP-001	001	DI-03	11
SPARE	SUB1-MCP-001	001	DI-03	12
SPARE	SUB1-MCP-001	001	DI-03	13
BKRb/DSBAT "BREAKER OPEN" STATUS	SUB1-MCP-001	001	DI-03	14
BKRa/DSBAT "BREAKER CLOSED" STATUS	SUB1-MCP-001	001	DI-03	15
SPARE	SUB1-MCP-001	001	DI-03	16
YA/ACU1 "AIR CONDITIONING UNIT NO. 1 FILTER CLOG" STATUS	SUB1-MCP-001	001	DI-04	01
YA/ACU1 "AIR CONDITIONING UNIT NO. 1 SMOKE DETECTION" STATUS	SUB1-MCP-001	001	DI-04	02
YA/ACU1 "AIR CONDITIONING UNIT NO. 1 COMMON FAIL" STATUS	SUB1-MCP-001	001	DI-04	03
YA/ACU1 "AIR CONDITIONING UNIT NO. 1 WATER DETECTION" STATUS	SUB1-MCP-001	001	DI-04	04
SPARE	SUB1-MCP-001	001	DI-04	05
SPARE	SUB1-MCP-001	001	DI-04	06
SPARE	SUB1-MCP-001	001	DI-04	07
SPARE	SUB1-MCP-001	001	DI-04	08
M/F1 "SCRUBBER NO. 1 MOTOR ON" STATUS	SUB1-MCP-001	001	DI-04	09
49X/F1 "SCRUBBER NO. 1 MOTOR OVERLOAD AUXILIARY RELAY" STATUS	SUB1-MCP-001	001	DI-04	10
SPARE	SUB1-MCP-001	001	DI-04	11
OP/AVD101 "SCRUBBER NO. 1 OUTSIDE AIR DAMPER POSITION OPEN" STATUS	SUB1-MCP-001	001	DI-04	12
CL/AVD101 "SCRUBBER NO. 1 OUTSIDE AIR DAMPER POSITION CLOSED" STATUS	SUB1-MCP-001	001	DI-04	13
SPARE	SUB1-MCP-001	001	DI-04	14
SPARE	SUB1-MCP-001	001	DI-04	15
SPARE	SUB1-MCP-001	001	DI-04	16
YA/ACU2 "AIR CONDITIONING UNIT NO. 2 FILTER CLOG" STATUS	SUB1-MCP-001	001	DI-05	01
YA/ACU2 "AIR CONDITIONING UNIT NO. 2 SMOKE DETECTION" STATUS	SUB1-MCP-001	001	DI-05	02
YA/ACU2 "AIR CONDITIONING UNIT NO. 2 COMMON FAIL" STATUS	SUB1-MCP-001	001	DI-05	03
YA/ACU2 "AIR CONDITIONING UNIT NO. 2 WATER DETECTION" STATUS	SUB1-MCP-001	001	DI-05	04
SPARE	SUB1-MCP-001	001	DI-05	05

SUBSTATION NO. 1

DESCRIPTION	PANEL	RACK	MODULE	PT.
SPARE	SUB1-MCP-001	001	DI-05	06
SPARE	SUB1-MCP-001	001	DI-05	07
SPARE	SUB1-MCP-001	001	DI-05	08
M/F2 "SCRUBBER NO. 2 MOTOR ON" STATUS	SUB1-MCP-001	001	DI-05	09
49X/F2 "SCRUBBER NO. 2 MOTOR OVERLOAD AUXILIARY RELAY" STATUS	SUB1-MCP-001	001	DI-05	10
SPARE	SUB1-MCP-001	001	DI-05	11
OP/AVD201 "SCRUBBER NO. 2 OUTSIDE AIR DAMPER POSITION OPEN" STATUS	SUB1-MCP-001	001	DI-05	12
CL/AVD201 "SCRUBBER NO. 2 OUTSIDE AIR DAMPER POSITION CLOSED" STATUS	SUB1-MCP-001	001	DI-05	13
SPARE	SUB1-MCP-001	001	DI-05	14
SPARE	SUB1-MCP-001	001	DI-05	15
SPARE	SUB1-MCP-001	001	DI-05	16
CAR/SUB1 "SUBSTATION COMMON ALARM"	SUB1-MCP-001	001	DO-01	01
SPARE	SUB1-MCP-001	001	DO-01	02
SPARE	SUB1-MCP-001	001	DO-01	03
SPARE	SUB1-MCP-001	001	DO-01	04
SPARE	SUB1-MCP-001	001	DO-01	05
SPARE	SUB1-MCP-001	001	DO-01	06
SPARE	SUB1-MCP-001	001	DO-01	07
SPARE	SUB1-MCP-001	001	DO-01	08
52b/105 "BREAKER OPEN" STATUS	SUB1-MCP-001	002	DI-01	01
52a/105 "BREAKER CLOSED" STATUS	SUB1-MCP-001	002	DI-01	02
TOC/105 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	002	DI-01	03
TRAN/105 "TRANSFER" STATUS	SUB1-MCP-001	002	DI-01	04
86/105 "LOCKOUT" STATUS	SUB1-MCP-001	002	DI-01	05
FX/105 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	002	DI-01	06
SS2/105 "REMOTE POSITION" STATUS	SUB1-MCP-001	002	DI-01	07
SS2/105 "LOCAL POSITION" STATUS	SUB1-MCP-001	002	DI-01	08
PMRSV/105 "BREAKER CLOSE PERMISSIVE" AUXILIARY RELAY STATUS	SUB1-MCP-001	002	DI-01	09
PMRSV/106 "BREAKER CLOSE PERMISSIVE" AUXILIARY RELAY STATUS	SUB1-MCP-001	002	DI-01	10
107PV/SMR1 "LINK BREAKER CLOSE PERMISSIVE NO. 1" STATUS	SUB1-MCP-001	002	DI-01	11
S1L1PV/SMR1 "MAIN/TIE BREAKER CLOSE PERMISSIVE NO. 1" STATUS	SUB1-MCP-001	002	DI-01	12
1R05b/SMR1 "SUBSTATION NO. 2 BREAKER 1R05 OPEN" STATUS	SUB1-MCP-001	002	DI-01	13
1R06b/SMR1 "SUBSTATION NO. 2 BREAKER 1R06 OPEN" STATUS	SUB1-MCP-001	002	DI-01	14
1R10b/SMR1 "SUBSTATION NO. 2 BREAKER 1R10 OPEN" STATUS	SUB1-MCP-001	002	DI-01	15

SUBSTATION NO. 1

DESCRIPTION	PANEL	RACK	MODULE	PT.
SPARE	SUB1-MCP-001	002	DI-01	16
52b/205 "BREAKER OPEN" STATUS	SUB1-MCP-001	002	DI-02	01
52a/205 "BREAKER CLOSED" STATUS	SUB1-MCP-001	002	DI-02	02
TOC/205 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	002	DI-02	03
TRAN/205 "TRANSFER" STATUS	SUB1-MCP-001	002	DI-02	04
86/205 "LOCKOUT" STATUS	SUB1-MCP-001	002	DI-02	05
FX/205 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	002	DI-02	06
SS2/205 "REMOTE POSITION" STATUS	SUB1-MCP-001	002	DI-02	07
SS2/205 "LOCAL POSITION" STATUS	SUB1-MCP-001	002	DI-02	08
PMRSV/205 "BREAKER CLOSE PERMISSIVE" AUXILIARY RELAY STATUS	SUB1-MCP-001	002	DI-02	09
PMRSV/206 "BREAKER CLOSE PERMISSIVE" AUXILIARY RELAY STATUS	SUB1-MCP-001	002	DI-02	10
207PV/SMR1 "LINK BREAKER CLOSE PERMISSIVE NO. 2" STATUS	SUB1-MCP-001	002	DI-02	11
S1L2PV/SMR1 "MAIN/TIE BREAKER CLOSE PERMISSIVE NO. 2" STATUS	SUB1-MCP-001	002	DI-02	12
1L05b/SMR1 "SUBSTATION NO. 2 BREAKER 1L05 OPEN" STATUS	SUB1-MCP-001	002	DI-02	13
1L06b/SMR1 "SUBSTATION NO. 2 BREAKER 1L06 OPEN" STATUS	SUB1-MCP-001	002	DI-02	14
1L10b/SMR1 "SUBSTATION NO. 2 BREAKER 1L10 OPEN" STATUS	SUB1-MCP-001	002	DI-02	15
SPARE	SUB1-MCP-001	002	DI-02	16
52b/106 "BREAKER OPEN" STATUS	SUB1-MCP-001	002	DI-03	01
52a/106 "BREAKER CLOSED" STATUS	SUB1-MCP-001	002	DI-03	02
TOC/106 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	002	DI-03	03
SX1/106 "SYNC ENABLE" STATUS	SUB1-MCP-001	002	DI-03	04
86/106 "LOCKOUT" STATUS	SUB1-MCP-001	002	DI-03	05
FX/106 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	002	DI-03	06
SS2/106 "REMOTE POSITION" STATUS	SUB1-MCP-001	002	DI-03	07
SS2/106 "LOCAL POSITION" STATUS	SUB1-MCP-001	002	DI-03	08
SS3/106 "MANUAL POSITION" STATUS	SUB1-MCP-001	002	DI-03	09
SS3/106 "AUTO POSITION" STATUS	SUB1-MCP-001	002	DI-03	10
52b/206 "BREAKER OPEN" STATUS	SUB1-MCP-001	002	DI-03	11
52a/206 "BREAKER CLOSED" STATUS	SUB1-MCP-001	002	DI-03	12
TOC/206 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	002	DI-03	13
SS2/206 "REMOTE POSITION" STATUS	SUB1-MCP-001	002	DI-03	14
SS2/206 "LOCAL POSITION" STATUS	SUB1-MCP-001	002	DI-03	15
SPARE	SUB1-MCP-001	002	DI-03	16
OIR/105 "OPEN BREAKER" COMMAND	SUB1-MCP-001	002	DO-01	01

SUBSTATION NO. 1

DESCRIPTION	PANEL	RACK	MODULE	PT.
CIR/105 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	002	DO-01	02
SPARE	SUB1-MCP-001	002	DO-01	03
SPARE	SUB1-MCP-001	002	DO-01	04
SPARE	SUB1-MCP-001	002	DO-01	05
SPARE	SUB1-MCP-001	002	DO-01	06
SPARE	SUB1-MCP-001	002	DO-01	07
SPARE	SUB1-MCP-001	002	DO-01	08
OIR/205 "OPEN BREAKER" COMMAND	SUB1-MCP-001	002	DO-02	01
CIR/205 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	002	DO-02	02
SPARE	SUB1-MCP-001	002	DO-02	03
SPARE	SUB1-MCP-001	002	DO-02	04
SPARE	SUB1-MCP-001	002	DO-02	05
SPARE	SUB1-MCP-001	002	DO-02	06
SPARE	SUB1-MCP-001	002	DO-02	07
SPARE	SUB1-MCP-001	002	DO-02	08
OIR/106 "OPEN BREAKER" COMMAND	SUB1-MCP-001	002	DO-03	01
CIR/106 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	002	DO-03	02
SPARE	SUB1-MCP-001	002	DO-03	03
SPARE	SUB1-MCP-001	002	DO-03	04
OIR/206 "OPEN BREAKER" COMMAND	SUB1-MCP-001	002	DO-03	05
CIR/206 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	002	DO-03	06
SPARE	SUB1-MCP-001	002	DO-03	07
SPARE	SUB1-MCP-001	002	DO-03	08
52b/103 "BREAKER OPEN" STATUS	SUB1-MCP-001	003	DI-01	01
52a/103 "BREAKER CLOSED" STATUS	SUB1-MCP-001	003	DI-01	02
TOC/103 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	003	DI-01	03
86/103 "LOCKOUT" STATUS	SUB1-MCP-001	003	DI-01	04
FX/103 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	003	DI-01	05
SS2/103 "REMOTE POSITION" STATUS	SUB1-MCP-001	003	DI-01	06
SS2/103 "LOCAL POSITION" STATUS	SUB1-MCP-001	003	DI-01	07
SPARE	SUB1-MCP-001	003	DI-01	08
52b/107 "BREAKER OPEN" STATUS	SUB1-MCP-001	003	DI-01	09
52a/107 "BREAKER CLOSED" STATUS	SUB1-MCP-001	003	DI-01	10
TOC/107 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	003	DI-01	11

SUBSTATION NO. 1

DESCRIPTION	PANEL	RACK	MODULE	PT.
86/107 "LOCKOUT" STATUS	SUB1-MCP-001	003	DI-01	12
FX/107 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	003	DI-01	13
SS2/107 "REMOTE POSITION" STATUS	SUB1-MCP-001	003	DI-01	14
SS2/107 "LOCAL POSITION" STATUS	SUB1-MCP-001	003	DI-01	15
SPARE	SUB1-MCP-001	003	DI-01	16
52b/108 "BREAKER OPEN" STATUS	SUB1-MCP-001	003	DI-02	01
52a/108 "BREAKER CLOSED" STATUS	SUB1-MCP-001	003	DI-02	02
TOC/108 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	003	DI-02	03
86/108 "LOCKOUT" STATUS	SUB1-MCP-001	003	DI-02	04
FX/108 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	003	DI-02	05
SS2/108 "REMOTE POSITION" STATUS	SUB1-MCP-001	003	DI-02	06
SS2/108 "LOCAL POSITION" STATUS	SUB1-MCP-001	003	DI-02	07
SPARE	SUB1-MCP-001	003	DI-02	08
52b/109 "BREAKER OPEN" STATUS	SUB1-MCP-001	003	DI-02	09
52a/109 "BREAKER CLOSED" STATUS	SUB1-MCP-001	003	DI-02	10
TOC/109 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	003	DI-02	11
86/109 "LOCKOUT" STATUS	SUB1-MCP-001	003	DI-02	12
FX/109 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	003	DI-02	13
SS2/109 "REMOTE POSITION" STATUS	SUB1-MCP-001	003	DI-02	14
SS2/109 "LOCAL POSITION" STATUS	SUB1-MCP-001	003	DI-02	15
SPARE	SUB1-MCP-001	003	DI-02	16
52b/110 "BREAKER OPEN" STATUS	SUB1-MCP-001	003	DI-03	01
52a/110 "BREAKER CLOSED" STATUS	SUB1-MCP-001	003	DI-03	02
TOC/110 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	003	DI-03	03
86/110 "LOCKOUT" STATUS	SUB1-MCP-001	003	DI-03	04
FX/110 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	003	DI-03	05
SS2/110 "REMOTE POSITION" STATUS	SUB1-MCP-001	003	DI-03	06
SS2/110 "LOCAL POSITION" STATUS	SUB1-MCP-001	003	DI-03	07
SPARE	SUB1-MCP-001	003	DI-03	08
52b/111 "BREAKER OPEN" STATUS	SUB1-MCP-001	003	DI-03	09
52a/111 "BREAKER CLOSED" STATUS	SUB1-MCP-001	003	DI-03	10
TOC/111 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	003	DI-03	11
86/111 "LOCKOUT" STATUS	SUB1-MCP-001	003	DI-03	12
FX/111 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	003	DI-03	13

SUBSTATION NO. 1

DESCRIPTION	PANEL	RACK	MODULE	PT.
SS2/111 "REMOTE POSITION" STATUS	SUB1-MCP-001	003	DI-03	14
SS2/111 "LOCAL POSITION" STATUS	SUB1-MCP-001	003	DI-03	15
SPARE	SUB1-MCP-001	003	DI-03	16
52b/112 "BREAKER OPEN" STATUS	SUB1-MCP-001	003	DI-04	01
52a/112 "BREAKER CLOSED" STATUS	SUB1-MCP-001	003	DI-04	02
TOC/112 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	003	DI-04	03
86/112 "LOCKOUT" STATUS	SUB1-MCP-001	003	DI-04	04
FX/112 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	003	DI-04	05
SS2/112 "REMOTE POSITION" STATUS	SUB1-MCP-001	003	DI-04	06
SS2/112 "LOCAL POSITION" STATUS	SUB1-MCP-001	003	DI-04	07
SPARE	SUB1-MCP-001	003	DI-04	08
52b/113 "BREAKER OPEN" STATUS	SUB1-MCP-001	003	DI-04	09
52a/113 "BREAKER CLOSED" STATUS	SUB1-MCP-001	003	DI-04	10
TOC/113 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	003	DI-04	11
86/113 "LOCKOUT" STATUS	SUB1-MCP-001	003	DI-04	12
FX/113 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	003	DI-04	13
SS2/113 "REMOTE POSITION" STATUS	SUB1-MCP-001	003	DI-04	14
SS2/113 "LOCAL POSITION" STATUS	SUB1-MCP-001	003	DI-04	15
SPARE	SUB1-MCP-001	003	DI-04	16
52b/114 "BREAKER OPEN" STATUS	SUB1-MCP-001	003	DI-05	01
52a/114 "BREAKER CLOSED" STATUS	SUB1-MCP-001	003	DI-05	02
TOC/114 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	003	DI-05	03
86/114 "LOCKOUT" STATUS	SUB1-MCP-001	003	DI-05	04
FX/114 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	003	DI-05	05
SS2/114 "REMOTE POSITION" STATUS	SUB1-MCP-001	003	DI-05	06
SS2/114 "LOCAL POSITION" STATUS	SUB1-MCP-001	003	DI-05	07
SPARE	SUB1-MCP-001	003	DI-05	08
52b/115 "BREAKER OPEN" STATUS	SUB1-MCP-001	003	DI-05	09
52a/115 "BREAKER CLOSED" STATUS	SUB1-MCP-001	003	DI-05	10
TOC/115 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	003	DI-05	11
86/115 "LOCKOUT" STATUS	SUB1-MCP-001	003	DI-05	12
FX/115 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	003	DI-05	13
SS2/115 "REMOTE POSITION" STATUS	SUB1-MCP-001	003	DI-05	14
SS2/115 "LOCAL POSITION" STATUS	SUB1-MCP-001	003	DI-05	15

SUBSTATION NO. 1

DESCRIPTION	PANEL	RACK	MODULE	PT.
SPARE	SUB1-MCP-001	003	DI-05	16
52b/116 "BREAKER OPEN" STATUS	SUB1-MCP-001	003	DI-06	01
52a/116 "BREAKER CLOSED" STATUS	SUB1-MCP-001	003	DI-06	02
TOC/116 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	003	DI-06	03
86/116 "LOCKOUT" STATUS	SUB1-MCP-001	003	DI-06	04
FX/116 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	003	DI-06	05
SS2/116 "REMOTE POSITION" STATUS	SUB1-MCP-001	003	DI-06	06
SS2/116 "LOCAL POSITION" STATUS	SUB1-MCP-001	003	DI-06	07
SPARE	SUB1-MCP-001	003	DI-06	08
52b/117 "BREAKER OPEN" STATUS	SUB1-MCP-001	003	DI-06	09
52a/117 "BREAKER CLOSED" STATUS	SUB1-MCP-001	003	DI-06	10
TOC/117 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	003	DI-06	11
86/117 "LOCKOUT" STATUS	SUB1-MCP-001	003	DI-06	12
FX/117 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	003	DI-06	13
SS2/117 "REMOTE POSITION" STATUS	SUB1-MCP-001	003	DI-06	14
SS2/117 "LOCAL POSITION" STATUS	SUB1-MCP-001	003	DI-06	15
SPARE	SUB1-MCP-001	003	DI-06	16
OIR/103 "OPEN BREAKER" COMMAND	SUB1-MCP-001	003	DO-01	01
CIR/103 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	003	DO-01	02
SPARE	SUB1-MCP-001	003	DO-01	03
SPARE	SUB1-MCP-001	003	DO-01	04
OIR/107 "OPEN BREAKER" COMMAND	SUB1-MCP-001	003	DO-01	05
CIR/107 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	003	DO-01	06
SPARE	SUB1-MCP-001	003	DO-01	07
SPARE	SUB1-MCP-001	003	DO-01	08
OIR/108 "OPEN BREAKER" COMMAND	SUB1-MCP-001	003	DO-02	01
CIR/108 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	003	DO-02	02
SPARE	SUB1-MCP-001	003	DO-02	03
SPARE	SUB1-MCP-001	003	DO-02	04
OIR/109 "OPEN BREAKER" COMMAND	SUB1-MCP-001	003	DO-02	05
CIR/109 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	003	DO-02	06
SPARE	SUB1-MCP-001	003	DO-02	07
SPARE	SUB1-MCP-001	003	DO-02	08
OIR/110 "OPEN BREAKER" COMMAND	SUB1-MCP-001	003	DO-03	01

SUBSTATION NO. 1

DESCRIPTION	PANEL	RACK	MODULE	PT.
CIR/110 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	003	DO-03	02
SPARE	SUB1-MCP-001	003	DO-03	03
SPARE	SUB1-MCP-001	003	DO-03	04
OIR/111 "OPEN BREAKER" COMMAND	SUB1-MCP-001	003	DO-03	05
CIR/111 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	003	DO-03	06
SPARE	SUB1-MCP-001	003	DO-03	07
SPARE	SUB1-MCP-001	003	DO-03	08
OIR/112 "OPEN BREAKER" COMMAND	SUB1-MCP-001	003	DO-04	01
CIR/112 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	003	DO-04	02
SPARE	SUB1-MCP-001	003	DO-04	03
SPARE	SUB1-MCP-001	003	DO-04	04
OIR/113 "OPEN BREAKER" COMMAND	SUB1-MCP-001	003	DO-04	05
CIR/113 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	003	DO-04	06
SPARE	SUB1-MCP-001	003	DO-04	07
SPARE	SUB1-MCP-001	003	DO-04	08
OIR/114 "OPEN BREAKER" COMMAND	SUB1-MCP-001	003	DO-05	01
CIR/114 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	003	DO-05	02
SPARE	SUB1-MCP-001	003	DO-05	03
SPARE	SUB1-MCP-001	003	DO-05	04
OIR/115 "OPEN BREAKER" COMMAND	SUB1-MCP-001	003	DO-05	05
CIR/115 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	003	DO-05	06
SPARE	SUB1-MCP-001	003	DO-05	07
SPARE	SUB1-MCP-001	003	DO-05	08
OIR/116 "OPEN BREAKER" COMMAND	SUB1-MCP-001	003	DO-06	01
CIR/116 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	003	DO-06	02
SPARE	SUB1-MCP-001	003	DO-06	03
SPARE	SUB1-MCP-001	003	DO-06	04
OIR/117 "OPEN BREAKER" COMMAND	SUB1-MCP-001	003	DO-06	05
CIR/117 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	003	DO-06	06
SPARE	SUB1-MCP-001	003	DO-06	07
SPARE	SUB1-MCP-001	003	DO-06	08
52b/203 "BREAKER OPEN" STATUS	SUB1-MCP-001	005	DI-01	01
52a/203 "BREAKER CLOSED" STATUS	SUB1-MCP-001	005	DI-01	02
TOC/203 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	005	DI-01	03

SUBSTATION NO. 1

DESCRIPTION	PANEL	RACK	MODULE	PT.
86/203 "LOCKOUT" STATUS	SUB1-MCP-001	005	DI-01	04
FX/203 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	005	DI-01	05
SS2/203 "REMOTE POSITION" STATUS	SUB1-MCP-001	005	DI-01	06
SS2/203 "LOCAL POSITION" STATUS	SUB1-MCP-001	005	DI-01	07
SPARE	SUB1-MCP-001	005	DI-01	08
52b/207 "BREAKER OPEN" STATUS	SUB1-MCP-001	005	DI-01	09
52a/207 "BREAKER CLOSED" STATUS	SUB1-MCP-001	005	DI-01	10
TOC/207 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	005	DI-01	11
86/207 "LOCKOUT" STATUS	SUB1-MCP-001	005	DI-01	12
FX/207 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	005	DI-01	13
SS2/207 "REMOTE POSITION" STATUS	SUB1-MCP-001	005	DI-01	14
SS2/207 "LOCAL POSITION" STATUS	SUB1-MCP-001	005	DI-01	15
SPARE	SUB1-MCP-001	005	DI-01	16
52b/208 "BREAKER OPEN" STATUS	SUB1-MCP-001	005	DI-02	01
52a/208 "BREAKER CLOSED" STATUS	SUB1-MCP-001	005	DI-02	02
TOC/208 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	005	DI-02	03
86/208 "LOCKOUT" STATUS	SUB1-MCP-001	005	DI-02	04
FX/208 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	005	DI-02	05
SS2/208 "REMOTE POSITION" STATUS	SUB1-MCP-001	005	DI-02	06
SS2/208 "LOCAL POSITION" STATUS	SUB1-MCP-001	005	DI-02	07
SPARE	SUB1-MCP-001	005	DI-02	08
52b/209 "BREAKER OPEN" STATUS	SUB1-MCP-001	005	DI-02	09
52a/209 "BREAKER CLOSED" STATUS	SUB1-MCP-001	005	DI-02	10
TOC/209 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	005	DI-02	11
86/209 "LOCKOUT" STATUS	SUB1-MCP-001	005	DI-02	12
FX/209 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	005	DI-02	13
SS2/209 "REMOTE POSITION" STATUS	SUB1-MCP-001	005	DI-02	14
SS2/209 "LOCAL POSITION" STATUS	SUB1-MCP-001	005	DI-02	15
SPARE	SUB1-MCP-001	005	DI-02	16
52b/210 "BREAKER OPEN" STATUS	SUB1-MCP-001	005	DI-03	01
52a/210 "BREAKER CLOSED" STATUS	SUB1-MCP-001	005	DI-03	02
TOC/210 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	005	DI-03	03
86/210 "LOCKOUT" STATUS	SUB1-MCP-001	005	DI-03	04
FX/210 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	005	DI-03	05

SUBSTATION NO. 1

DESCRIPTION	PANEL	RACK	MODULE	PT.
SS2/210 "REMOTE POSITION" STATUS	SUB1-MCP-001	005	DI-03	06
SS2/210 "LOCAL POSITION" STATUS	SUB1-MCP-001	005	DI-03	07
SPARE	SUB1-MCP-001	005	DI-03	08
52b/211 "BREAKER OPEN" STATUS	SUB1-MCP-001	005	DI-03	09
52a/211 "BREAKER CLOSED" STATUS	SUB1-MCP-001	005	DI-03	10
TOC/211 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	005	DI-03	11
86/211 "LOCKOUT" STATUS	SUB1-MCP-001	005	DI-03	12
FX/211 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	005	DI-03	13
SS2/211 "REMOTE POSITION" STATUS	SUB1-MCP-001	005	DI-03	14
SS2/211 "LOCAL POSITION" STATUS	SUB1-MCP-001	005	DI-03	15
SPARE	SUB1-MCP-001	005	DI-03	16
52b/212 "BREAKER OPEN" STATUS	SUB1-MCP-001	005	DI-04	01
52a/212 "BREAKER CLOSED" STATUS	SUB1-MCP-001	005	DI-04	02
TOC/212 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	005	DI-04	03
86/212 "LOCKOUT" STATUS	SUB1-MCP-001	005	DI-04	04
FX/212 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	005	DI-04	05
SS2/212 "REMOTE POSITION" STATUS	SUB1-MCP-001	005	DI-04	06
SS2/212 "LOCAL POSITION" STATUS	SUB1-MCP-001	005	DI-04	07
SPARE	SUB1-MCP-001	005	DI-04	08
52b/213 "BREAKER OPEN" STATUS	SUB1-MCP-001	005	DI-04	09
52a/213 "BREAKER CLOSED" STATUS	SUB1-MCP-001	005	DI-04	10
TOC/213 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	005	DI-04	11
86/213 "LOCKOUT" STATUS	SUB1-MCP-001	005	DI-04	12
FX/213 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	005	DI-04	13
SS2/213 "REMOTE POSITION" STATUS	SUB1-MCP-001	005	DI-04	14
SS2/213 "LOCAL POSITION" STATUS	SUB1-MCP-001	005	DI-04	15
SPARE	SUB1-MCP-001	005	DI-04	16
52b/214 "BREAKER OPEN" STATUS	SUB1-MCP-001	005	DI-05	01
52a/214 "BREAKER CLOSED" STATUS	SUB1-MCP-001	005	DI-05	02
TOC/214 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	005	DI-05	03
86/214 "LOCKOUT" STATUS	SUB1-MCP-001	005	DI-05	04
FX/214 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	005	DI-05	05
SS2/214 "REMOTE POSITION" STATUS	SUB1-MCP-001	005	DI-05	06
SS2/214 "LOCAL POSITION" STATUS	SUB1-MCP-001	005	DI-05	07

SUBSTATION NO. 1

DESCRIPTION	PANEL	RACK	MODULE	PT.
SPARE	SUB1-MCP-001	005	DI-05	08
52b/215 "BREAKER OPEN" STATUS	SUB1-MCP-001	005	DI-05	09
52a/215 "BREAKER CLOSED" STATUS	SUB1-MCP-001	005	DI-05	10
TOC/215 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	005	DI-05	11
86/215 "LOCKOUT" STATUS	SUB1-MCP-001	005	DI-05	12
FX/215 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	005	DI-05	13
SS2/215 "REMOTE POSITION" STATUS	SUB1-MCP-001	005	DI-05	14
SS2/215 "LOCAL POSITION" STATUS	SUB1-MCP-001	005	DI-05	15
SPARE	SUB1-MCP-001	005	DI-05	16
52b/216 "BREAKER OPEN" STATUS	SUB1-MCP-001	005	DI-06	01
52a/216 "BREAKER CLOSED" STATUS	SUB1-MCP-001	005	DI-06	02
TOC/216 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	005	DI-06	03
86/216 "LOCKOUT" STATUS	SUB1-MCP-001	005	DI-06	04
FX/216 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	005	DI-06	05
SS2/216 "REMOTE POSITION" STATUS	SUB1-MCP-001	005	DI-06	06
SS2/216 "LOCAL POSITION" STATUS	SUB1-MCP-001	005	DI-06	07
SPARE	SUB1-MCP-001	005	DI-06	08
52b/217 "BREAKER OPEN" STATUS	SUB1-MCP-001	005	DI-06	09
52a/217 "BREAKER CLOSED" STATUS	SUB1-MCP-001	005	DI-06	10
TOC/217 "BREAKER TRUCK POSITION" STATUS	SUB1-MCP-001	005	DI-06	11
86/217 "LOCKOUT" STATUS	SUB1-MCP-001	005	DI-06	12
FX/217 "PROTECTIVE RELAY FAILURE" STATUS	SUB1-MCP-001	005	DI-06	13
SS2/217 "REMOTE POSITION" STATUS	SUB1-MCP-001	005	DI-06	14
SS2/217 "LOCAL POSITION" STATUS	SUB1-MCP-001	005	DI-06	15
SPARE	SUB1-MCP-001	005	DI-06	16
OIR/203 "OPEN BREAKER" COMMAND	SUB1-MCP-001	005	DO-01	01
CIR/203 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	005	DO-01	02
SPARE	SUB1-MCP-001	005	DO-01	03
SPARE	SUB1-MCP-001	005	DO-01	04
OIR/207 "OPEN BREAKER" COMMAND	SUB1-MCP-001	005	DO-01	05
CIR/207 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	005	DO-01	06
SPARE	SUB1-MCP-001	005	DO-01	07
SPARE	SUB1-MCP-001	005	DO-01	08
OIR/208 "OPEN BREAKER" COMMAND	SUB1-MCP-001	005	DO-02	01

SUBSTATION NO. 1

DESCRIPTION	PANEL	RACK	MODULE	PT.
CIR/208 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	005	DO-02	02
SPARE	SUB1-MCP-001	005	DO-02	03
SPARE	SUB1-MCP-001	005	DO-02	04
OIR/209 "OPEN BREAKER" COMMAND	SUB1-MCP-001	005	DO-02	05
CIR/209 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	005	DO-02	06
SPARE	SUB1-MCP-001	005	DO-02	07
SPARE	SUB1-MCP-001	005	DO-02	08
OIR/210 "OPEN BREAKER" COMMAND	SUB1-MCP-001	005	DO-03	01
CIR/210 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	005	DO-03	02
SPARE	SUB1-MCP-001	005	DO-03	03
SPARE	SUB1-MCP-001	005	DO-03	04
OIR/211 "OPEN BREAKER" COMMAND	SUB1-MCP-001	005	DO-03	05
CIR/211 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	005	DO-03	06
SPARE	SUB1-MCP-001	005	DO-03	07
SPARE	SUB1-MCP-001	005	DO-03	08
OIR/212 "OPEN BREAKER" COMMAND	SUB1-MCP-001	005	DO-04	01
CIR/212 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	005	DO-04	02
SPARE	SUB1-MCP-001	005	DO-04	03
SPARE	SUB1-MCP-001	005	DO-04	04
OIR/213 "OPEN BREAKER" COMMAND	SUB1-MCP-001	005	DO-04	05
CIR/213 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	005	DO-04	06
SPARE	SUB1-MCP-001	005	DO-04	07
SPARE	SUB1-MCP-001	005	DO-04	08
OIR/214 "OPEN BREAKER" COMMAND	SUB1-MCP-001	005	DO-05	01
CIR/214 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	005	DO-05	02
SPARE	SUB1-MCP-001	005	DO-05	03
SPARE	SUB1-MCP-001	005	DO-05	04
OIR/215 "OPEN BREAKER" COMMAND	SUB1-MCP-001	005	DO-05	05
CIR/215 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	005	DO-05	06
SPARE	SUB1-MCP-001	005	DO-05	07
SPARE	SUB1-MCP-001	005	DO-05	08
OIR/216 "OPEN BREAKER" COMMAND	SUB1-MCP-001	005	DO-06	01
CIR/216 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	005	DO-06	02
SPARE	SUB1-MCP-001	005	DO-06	03

SUBSTATION NO. 1

DESCRIPTION	PANEL	RACK	MODULE	PT.
SPARE	SUB1-MCP-001	005	DO-06	04
OIR/217 "OPEN BREAKER" COMMAND	SUB1-MCP-001	005	DO-06	05
CIR/217 "CLOSE BREAKER" COMMAND	SUB1-MCP-001	005	DO-06	06
SPARE	SUB1-MCP-001	005	DO-06	07
SPARE	SUB1-MCP-001	005	DO-06	08