GRANGER-HUNTER IMPROVEMENT DISTRICT

ANDERSON WATER TREATMENT PLANT PROJECT

Volume II
BID SET
TECHNICAL SPECIFICATIONS

November **2024**

GRANGER-HUNTER
IMPROVEMENT DISTRICT

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GRANGER-HUNTER IMPROVEMENT DISTRICT
ANDERSON WATER TREATMENT PLANT
TECHNICAL SPECIFICATIONS

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SECTION 16000
ELECTRICAL GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 SCOPE

A. This Section consists of the Electrical General Requirements and related items necessary to provide complete and operational electrical system(s) indicated within the Contract Documents.

1.2 APPLICABLE SECTIONS AND REQUIREMENTS

A. The General Conditions, Supplementary Conditions, Special Conditions, Alternates and Addenda, applicable drawings, and the technical specifications herein shall apply to all work under this Division 16.

B. The CONTRACTOR shall comply with the specifications and accompanying drawings which describe and provide for the furnishing, delivering, installing, testing, and placing in satisfactory and successful operation all equipment, materials, devices, and necessary appurtenances to provide a complete electrical system for power distribution, control, lighting, and auxiliary systems.

C. State Licensed Contractor - All contractors must have a current state contracting license. The CONTRACTOR shall be licensed as such in the CONTRACTOR state of origin and in the state where the work is performed.

D. The electrical contractor shall have a licensed Master Electrician assigned to direct the electrical work and to coordinate work with the General Contractor and other trades. Furthermore, a licensed journeyman electrician shall be assigned to supervise the actual performance of all electrical work under Division 16.

E. The licensed journeyman assigned to supervise the performance of Division 16 electrical work, shall be required to be on the job site at all times, while Division 16 work is being performed.

1.3 CONTRACT DOCUMENTS

A. Contract documents consist of drawings, specifications, and other documents issued by the ENGINEER. Each is complementary and requirements shown, written or reasonably inferred there from on one is considered as written, shown or implied in all. In the event work is called for in more than one place and is of conflicting requirements, the right shall be reserved to require the installation of the larger or the more expensive.

B. The drawings are diagrammatic, intended to indicate the general scope and locations of the work to be installed and are not to be considered as complete in every detail, but shall be followed as closely as actual construction and work of other contractors will permit.

C. Data given herein and on drawings are as exact as could be secured, but their extreme accuracy is not guaranteed. Drawings and specifications are for the assistance and guidance of the CONTRACTOR; but exact locations, distances, and levels will be governed by actual conditions, and the CONTRACTOR is to verify all dimensions given on the drawings, and to report any discrepancy or inconsistency to the ENGINEER before commencing with the work.

D. The CONTRACTOR shall install all work indicated and/or specified herein, complete to perform the function intended without additional cost. Raceway and conductors to panels from devices referred to as "home runs" are indicated by pointing in the general direction of panels. Construction shall continue such circuits to the panels as though the routes were completely indicated. Home runs shall be installed from devices to panels as indicated.

E. Deviations from the drawings required to make work of this contract conform to actual conditions as constructed, or as to work of other contractors, shall be made by the CONTRACTOR at his expense. The ENGINEER reserves the right to make minor changes in the location of equipment and devices without additional charges.

F. The CONTRACTOR shall familiarize himself with the architectural, structural, and civil/mechanical drawings and shall study drawings and details so that equipment will be properly located and readily accessible. If any conflicts occur necessitating departures from the contract drawings, details of departures and reasons therefore shall be submitted for prior approval.

G. In any case and at any time, a change in material or location is made necessary by CONTRACTOR's failure to take into account obstacles or the installation of other trades shown, whether on electrical drawings or other drawings, in existence at the time bids were received, such changes shall be made without charge to OWNER.

H. Drawings are not intended to be scaled for rough-in measurements nor to serve as Shop Drawings. Where drawings are required for these purposes or have to be made from field measurements, they shall be prepared by the CONTRACTOR, Shop Drawings of various contractors shall be coordinated to take into account all obstacles that will interfere with the installation.

I. Every attempt has been made to indicate the installation and wiring requirements for all equipment to be installed. However, it shall be the CONTRACTOR’s responsibility to coordinate with equipment shop drawings and make adjustments necessary including; power and control wiring sizes and counts, breaker sizes, rough-in locations, etc. for actual equipment provided. The contractor shall provide in his bid the conductors and conduits required for the equipment to be installed. The contractor shall reference the mechanical drawings, the P&ID drawings, the control diagrams, the control drawings, the power drawings, the one line diagrams and all schedules. The contractor shall at his expense provide the conduit and conductors for the equipment installation for a complete and functional system.

J. Every attempt has been made in the drawings to indicate the general installation requirements for the power and control connections for the equipment indicated. However, equipment requirements vary from manufacturer to manufacturer and from date to date for equipment. The responsibility to coordinate the exact requirements of all equipment and install the required systems for these systems shall belong to the contractor, at his expense. No additional costs to the owner shall be incurred for the contractor's failure to coordinate these equipment requirements at the time of bid.

K. Electrical drawings are diagrammatic in nature and are not intended to show shop drawing style connections, equipment installation coordination or exact conduit and conductor sizes or counts. The contractor shall at his expense coordinate and provide necessary electrical and control components for a complete and functional system. If any conduit, equipment schedule, sizing, capacities, counts, lengths are unclear at the time of bidding or if conflicts exist on the drawings or in the specifications, the owner reserves the right for the installation of the more expensive or the more involved at no additional cost to the owner.

1.4 INFORMATION FOR ENGINEER

A. Submit the required information in accordance with the General Conditions, Section 01300, and the following requirements.

1. The CONTRACTOR shall check all shop drawings for conformance with Contract Documents before submitting. The CONTRACTOR shall note on shop drawings any changes from items specified listing reasons and giving source of change such as "Approved Equal", "Addendum", or "Change Order". The CONTRACTOR shall be responsible for conformance with drawings and specifications; for dimensions to be confirmed and correlated at the job site: for information that pertains solely to the fabrication processes or the techniques for construction; and coordination of the work with other trades. Receipt or approval of shop drawings by the ENGINEER does not relieve the CONTRACTOR of the responsibility of complying with Contract Documents.
2. All shop drawings (drawings and manufacturer's data) required under each section of this Division 16 shall be submitted at the same time and be bound together in one hard back, three ring binders per copy, properly indexed for the formal submittal. Binder shall be sized to adequately contain all the materials therein and shall be labeled as to the identity of the job and the sub-contractor.
3. Shop drawings shall include functional and descriptive literature of the particular item furnished complete with dimensional drawings, wiring or schematic diagrams, rough-in and installation instructions, knock-out locations, hangers or mounting devices, etc., as required for the proper checking and installation of the equipment. Catalog sheets without any reference made to the particular item will not be acceptable. All special features called for in Contract Documents shall be noted. Where performance test results of a product design are called for in the technical sections of these specifications, test data sheets shall be provided with the shop drawing submittal.

B. Material Lists: Include manufacturer, type and model number of equipment that will be provided as called for under each section of this Division 16.

C. Other Information: As required by the ENGINEER.

1.5 CODES, LICENSES AND STANDARDS

A. Perform work in accordance with best present-day installation and manufacturing practices. Comply with all applicable laws, building and construction codes, and requirements of governmental agencies under whose jurisdiction work is being performed. Unless specifically noted to contrary, conform with and test in accordance with applicable sections of latest revisions of the following codes and standards.

1. American Society for Testing and Materials (ASTM)
2. National Fire Protection Association (NFPA)
3. National Electrical Code (NFPA 70-NEC)
4. Insulated Power Cable Engineers Association (ICEA)
5. Underwriters Laboratories Inc. (UL)
6. American Steel and Iron Institute, "Design Manual on Steel Electrical Raceways"
7. National Electrical Manufacturer's Association (NEMA)
8. National Electrical Contractor’s Association (NECA)
9. American National Standards Institute (ANSI)
10. International Building Code (IBC)
11. State of Nevada Electrical, Energy, Building and Safety Codes
12. Institute of Electrical and Electronic Engineers (IEEE)
13. Instrument Society of America
14. Wastewater Treatment Plants (NFPA-820)

B. Conflicts Between Above Codes and Standards: The code or standard establishing the more stringent requirements shall be followed.

C. Conflicts Between Codes and Standards and Specifications and/or Drawings: The one establishing the more stringent requirements shall be followed.

1.6 MATERIALS AND WORKMANSHIP

A. Each type of equipment or material shall be the same make and quality. All materials and equipment shall be installed in accordance with the recommendations of the manufacturer as approved by the ENGINEER to conform to the Contract Documents. The installation shall be accomplished by workmen skilled in the type of work involved.

B. All materials and equipment furnished and installed shall be of best quality, new, free from defects and meet the standards of NEMA, ICEA, UL, NFPA, IBC, OSHA, NEC, and shall bear their label wherever standards have been established and label service is available. Where materials and equipment are specified by manufacturer's name, the type and quality required is thereby denoted. The ENGINEER shall be afforded every facility, deemed necessary to observe and examine the materials and apparatus being installed to prove their quality.

C. Workmanship shall be the best quality of its kind for the respective industry crafts and practices, be neat and orderly throughout the project and shall be acceptable in every respect to the ENGINEER. Nothing contained herein shall relieve the CONTRACTOR from making good and perfect work in all details of construction.

D. The CONTRACTOR shall work in harmony with the ENGINEER and with other contractor's, companies or individuals working in connection with this project. Imperfections or discrepancies by other contractors shall not relieve responsibility of this CONTRACTOR. Store materials orderly and clean up without interference with other trades.

1.7 DEFECTIVE EQUIPMENT

A. If equipment fails to conform to detailed specifications or to operate satisfactorily, the OWNER will have the right to operate equipment until defects are corrected.

1. The OWNER will have the right to operate rejected equipment until it is replaced, without cost for depreciation use or wear.
2. Remove equipment from operation for examination, adjustment, alteration or change only at times approved by the OWNER.

1.8 STORAGE AND PROTECTION OF MATERIALS

A. Provide storage space for storage of materials and apparatus and assume complete responsibility for all losses due to any cause whatsoever. In no case shall storage interfere with traffic conditions in any public thoroughfare or constitute a hazard to persons in the vicinity. Protect completed work, work under way, and apparatus against loss or damage.

B. Materials and apparatus shall be stored with environmental protection and other necessary conditions as recommend or required by the manufacturers'.

1.9 RECORD DRAWINGS

A. The Contract Document drawings will be used by the CONTRACTOR who shall accurately and neatly mark in colored pencil all changes or deviations from the drawings as they are made in the work.

B. Refer to Section "Closeout Procedures and Record Drawings" for additional requirements.

1.10 COORDINATION OF CONSTRUCTION

A. Coordinate work with other contractors, the OWNER, and the ENGINEER to assure orderly and expeditious progress of work. Select order of work and establish schedule of working hours for construction. This is subject to review by the OWNER if the work involved is part of a functioning facility. If such is the case, the CONTRACTOR shall carefully coordinate any disruption of service with the OWNER. Any after hours/weekend outages shall be accommodated at no additional cost to the OWNER.

B. The electrical work shall be laid out in advance of construction to eliminate unnecessary cutting, drilling, or channeling, etc. Where such cutting and drilling, or channeling becomes necessary for proper installation; perform with care, use skilled mechanics of the trades involved. Repair damage to building and equipment at no additional cost to the OWNER. Cutting work of other trades shall be done only with the consent of the CONTRACTOR. Cutting of structural members shall be done only with the written approval of the ENGINEER.

C. Comply with the following:

1. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
2. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
3. Install systems, materials and equipment giving right-of-way priority to systems required to be installed at a specified slope.

D. Cooperate with other trades to coordinate locations of electrical devices and apparatus.

E. Perform for other trades the electrical wiring and connections, for all devices or apparatus where not specified herein or indicated on the drawings. Consult the architectural and mechanical drawings to avoid the location of switches, outlets, and other equipment from being hidden behind doors, cabinets, counters, heating equipment, etc. Hidden electrical devices and/or connections shall be relocated as directed, at no additional cost to the OWNER.

F. Where conduit, outlets or apparatus is to be cast in concrete or encased, it must be located and secured by a journeyman or foreman present at the point of installation. He shall check the locations of the electrical items before and after the concrete and masonry installation and shall relocate displaced items at no additional cost

1.11 <u>USE OF SUBSTITUTES</u>

A. Equipment and materials are designated by one or more manufacturer's name brands or numbers. It is not the intent of the specifications to exclude other equipment or materials that equal or exceed the standard of those specified. If the CONTRACTOR desires to use substitute equipment or materials, he must submit for written approval as outlined in the General Conditions of the Contract Documents.

1.12 <u>SITE CONDITIONS</u>

A. Examination Of Site: Examination of the site shall be made by the CONTRACTOR, who shall compare it with the drawings and specifications and satisfy himself as to the conditions under which the work is to be performed. He shall, at such time, ascertain and check all conditions which may affect his work. No allowance shall subsequently be made in his behalf for any extra expenses to which he may be put due to failure or neglect on his part to make such examination.

B. Review of Plans: Review all work indicated on drawings and specified herein with proper authorities responsible for interpreting applicable codes, ENGINEER, and local inspector prior to commencement with construction as listed herein, but not necessarily limited thereto:

1. Visit site prior to executing bid.
2. Verify measurements and locations of field measurements of existing conditions and those developed by construction.
3. Confirm requirements of work at off-site, publicly owned property with local authorities
4. Confirm connection requirements, sizes and layout with local public utilities.
5. Conditions discovered in conflict with intent of drawings and/or specifications must be clarified with ENGINEER prior to execution of work.

1.13 CLEAN-UP

A. As the work progresses and on a daily basis, the CONTRACTOR shall remove from the premises and surrounding streets, alleys, etc., all rubbish and debris resulting from his operations and shall leave all equipment and material furnished by him absolutely clean and ready for use.

1.14 SUPERVISION:

A. A competent foreman or superintendent initially approved by the ENGINEER shall be at the site at all times to receive instructions and shall be empowered to act. He shall verify dimensions given on the drawings and report any discrepancies or inconsistencies to the ENGINEER before commencing the work. The ENGINEER, or his representative, will interpret the meaning of the drawings and specifications where questions arise.

1.15 SAFETY REGULATIONS

A. The CONTRACTOR shall comply with OSHA and all other safety codes required by law and shall furnish and place proper protection for prevention of accidents. He/she shall provide and maintain any necessary construction required to secure safety of life or property during the performance of his/her work, including the maintenance of sufficient lights to secure such protection.

1.16 DISPOSITION OF EXISTING EQUIPMENT REMOVED FROM SERVICE

A. Existing equipment and materials such as cables, switches, conductors, etc., which are removed and not reused in the new installation shall remain the property of the OWNER. The CONTRACTOR shall deliver such equipment to storage place as directed. Items not wanted by the OWNER shall be removed from the site and disposed of by the CONTRACTOR.

1.17 PERMITS AND FEES

A. Obtain all permits and pay all fees for inspections, required by code for all the work covered under Division 16 of the specifications. All fees shall be included in the contract price. The CONTRACTOR shall furnish a certificate of approval to the ENGINEER from each inspection authority at completion of the work.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1 FIELD DESIGN CHANGES

A. No field changes, additions, or change in locations shall be made without written approval from the ENGINEER.

3.2 EXCAVATION AND BACKFILLING

A. The CONTRACTOR shall perform all excavation, trenching and backfilling work, and remove all debris in connection with his work. Backfilling shall be done with materials acceptable to the ENGINEER and thoroughly tamped in place. All disturbed surfaces shall be restored to their original condition and properly installed to eliminate any settlement. Inside and outside, backfill shall be in 6-inch layers, compacted to 95% of the "standard protector test".

B. Perform excavation in a manner to protect walls, footings and other structural members, from being disturbed or damaged in any way.

3.3 ROUGH-IN REQUIREMENTS

A. Architectural, structural and mechanical drawings shall be continually consulted and referred to. Exact placement of sleeves, conduit, and equipment shall be provided for by checking building and equipment dimensions. Equipment requirements and dimensions related there to shall be determined from detailed rough-in dimensions of each piece of equipment shown on Shop Drawings furnished by manufacturer.

3.4 CUTTING AND PATCHING CHASES AND OPENINGS

A. Provide for all required cutting and patching, anchors, openings, slots, chases, etc., in construction for electrical work. Cutting and patching performed under direction of CONTRACTOR and will leave no discernable scars.

B. The CONTRACTOR shall be responsible for block-outs or demolition work pertaining to the installation of the electrical system.

C. In Remodeling and/or Addition projects, all salvageable electrical equipment and materials that cannot be integrated into the new electrical network becomes the property of the OWNER. Remove from the premises materials which the OWNER decides not to keep, as directed by the ENGINEER.

3.5 WORKMANSHIP

A. The CONTRACTOR shall be held solely responsible for the proper installation of his work. He shall arrange with the proper contractors for the building in of anchors, etc., and for the leaving of required chases, openings, etc., and shall do all cutting and patching made necessary by his failure or neglect to make such arrangements with others. Any cutting or patching done by this CONTRACTOR shall be subject to the directions of the ENGINEER and shall not be started until approval has been obtained.

B. All cutting, welding or drilling of concrete or structural members shall be properly reinforced and patched to match as nearly as possible the surrounding work. Before cutting, welding or drilling any concrete or structural member, the CONTRACTOR shall secure the approval of the ENGINEER.

C. This CONTRACTOR shall assign persons in direct charge of work who are thoroughly experienced in the class of construction work specified herein. All labor shall be performed in a workman like manner by skilled workmen under the supervision of competent foremen.

D. This CONTRACTOR shall periodically remove all debris and waste in order to maintain safe working and operating conditions, and shall dispose of the same in an approved manner. At the completion of work, he shall remove all his rubbish, tools, scaffolds and surplus materials from and about the site, leaving his work clean and the areas ready for occupancy.

3.6 SEISMIC RESTRAINT

A. The International Building Code requires that not only the structure, but also major mechanical and electrical components be designed and installed in a manner which will preclude damage during a seismic event. All electrical equipment shall be securely anchored and seismic braced in accordance with regulations contained in the most recent adopted edition of the IBC, and SMACNA "Guidelines for Seismic Restraints of Electrical Systems".

B. Units mounted and secured directly to structure shall be provided with connectors of sufficient strength to meet the restraining criteria.

C. All electrical equipment which is securely anchored (hard mounted) to the building or structure shall have supports designed to withstand lateral and vertical "G" loadings equal to or greater than IBC requirements and SMACNA guidelines.

D. Shop drawings are required for all equipment anchors, supports and seismic restraints. Submittals shall include weights, dimensions, load/deflection data, center of gravity, standard connections, manufacturer's recommendations, and behavior problems (vibration, thermal, expansion, etc.) associated with equipment so that the final design can be properly reviewed.

3.7 TESTS

A. On completion of the work, the installation shall be tested free from all grounds and short circuits.

B. Normal feeders, circuits, and service entrance conductors with wire size #2 and larger shall be tested for leakage phase-to-ground and phase-to-phase prior to energizing the electrical system. The CONTRACTOR shall submit a written report to the ENGINEER showing methods and readings taken. Voltage applied for testing shall not exceed two times normal operating voltage.

C. Submit a record of voltage readings and amp meter readings on all feeders, motor full load amps, outside lighting, and service conductors to the facility. If there are any abnormal conditions, they shall be brought to the attention of the ENGINEER in writing as a part of this submittal.

D. Refer to Section "Electrical Acceptance Tests" for additional requirements.

3.8 SUBSTANTIAL AND FINAL COMPLETION

A. Notify the ENGINEER when work is considered to be complete, in operating condition, and ready for Substantial Completion.

B. The ENGINEER, after determining that installation is ready for Substantial Completion, will make walkthrough and perform operational tests deemed necessary to determine that provisions of specifications are satisfied and prepare a list of outstanding items.

C. The OWNER will not accept work nor make final payment to CONTRACTOR until ENGINEER has certified that work of CONTRACTOR is complete and in conformance with specifications and guarantees.

D. Leave the job in complete order ready for use. All fixtures and equipment shall be tight, fully equipped and completely cleaned. All equipment shall have been operated, checked and approved by the OWNER before the project can be accepted.

E. At the time of the substantial and final walkthroughs, the project foreman shall accompany the party and remove cover plates, panel and enclosure covers, and other access panels for the ENGINEER, to allow complete observation of the entire electrical system(s).

F. Notify the ENGINEER when work is considered to be complete, including list of outstanding items, and is ready for Final Completion. Refer to Section "Closeout Procedures and Record Documents" for additional requirements.

3.9 TRAINING

A. Instruct OWNER's operating personnel in proper operation of the complete electrical system including all electrical equipment, switching, disconnects, panels, controls, etc., during a scheduled training tour for the OWNER's personnel of entire project after Substantial Completion and prior to Final Completion. Confirm complete understanding on part of OWNER's operating personnel. Utilize the Operations and Maintenance Manuals specified elsewhere during the instruction process.

3.10 GUARANTEE/WARRANTY

A. The following guarantee is a part of the specification and shall be binding on the part of the CONTRACTOR and shall be submitted by letter to the OWNER prior to acceptance.

B. The CONTRACTOR guarantees that this installation complies with the drawings and specifications in all respects, and is free from defects. He agrees to replace or repair, to the satisfaction of the ENGINEER, any part of this installation which may fail or be determined unacceptable within a period of one (1) year after Final Completion.

C. The CONTRACTOR guarantees that the installation of OWNER furnished equipment is free from defects. He agrees to provide labor to repair or replace to the satisfaction of the ENGINEER any part of his installation of the OWNER furnished equipment (the respective equipment vendor will provide all parts and labor for the equipment), which may fail or be determined to be unacceptable within a period of one (1) year after Final Completion.

D. Electrical and instrumentation systems and equipment shall not be considered acceptable for Substantial Completion until they have performed in service continuously without malfunction for at least ten (10) days.

END OF SECTION

SECTION 16060
GROUNDING AND BONDING

PART 1 - GENERAL

1.1 SCOPE

A. Furnish all labor, materials, equipment, appliances, and perform all operations in connection with, and complete in strict accordance with, this section of specifications and the applicable drawings and subject to the terms and conditions of the contract for the following work:

1. Grounding electrodes and conductors.
2. Equipment grounding conductors.

1.2 APPLICABLE SECTIONS

A. The General Conditions, Supplementary Conditions, alternates and Addenda, applicable drawings and the technical specification including but not limited to the following:

1. Section “Electrical General Requirements”.

1.3 REFERENCES

A. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems (International Electrical Testing Association).

B. NFPA 70 - National Electrical Code.

1.4 GROUNDING SYSTEM DESCRIPTION

A. Metal underground water pipe.

B. Metal frame of the building.

C. Concrete-encased electrode.

D. Rod electrode.

E. Plate electrode.

F. Active electrode.

1.5 PERFORMANCE REQUIREMENTS

A. Grounding System Resistance: 25 ohms maximum.

1.6 SUBMITTALS FOR REVIEW

A. Section Submittals: General.

B. Section Submittals: Procedures for submittals.

C. Product Data: Provide for grounding and bonding equipment.

D. All submittals shall include a list of all items being submitted by description, manufacturer and catalog number.

1.7 SUBMITTALS FOR CLOSEOUT

A. Section “Operation and Maintenance Manuals”.

B. Project Record Documents: Record actual locations of components and grounding electrodes.

C. Certificate of Compliance: Indicate approval of installation by the authority having jurisdiction.

1.8 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum 5 years documented experience.

1.9 REGULATORY REQUIREMENTS

A. Conform to requirements of NFPA 70.

B. Products: Listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

PART 2 - PRODUCTS

2.1 ROD ELECTRODES

A. Material: Copper Clad Steel.

B. Diameter: 5/8 inch.

C. Length: 10 feet (3000 mm).

2.2 CONNECTORS

A. Manufacturers:
   1. T&B
   2. Burndy - Hi-Ground
   3. ERICO® - Cadweld®

B. Material: Irreversible Crimp Style or Exothermic Weld.

2.3 WIRE

C. Material: Stranded copper, tinned.

D. Grounding Electrode Conductor: Size as indicated in the Drawings, or if modified or not indicated, size to meet NFPA 70 requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that final backfill and compaction has been completed before driving rod electrodes.

3.2 INSTALLATION

A. Install electrodes at locations indicated and in accordance with manufacturer’s instructions. Install additional rod electrodes as required to achieve specified resistance to ground.

B. Provide grounding electrode conductor (UFER) and connect to reinforcing steel in foundation footing. Bond steel together.

C. Provide bonding to meet Regulatory Requirements.

3.3 FIELD QUALITY CONTROL

A. Perform inspections and tests listed in NFPA ATS, Section 7.13.

END OF SECTION

SECTION 16100

LIGHTNING PROTECTION

PART 1 - GENERAL

1.1 SCOPE

Furnish all labor, materials, equipment, appliances and perform all operations in connection with, and complete in strict accordance with, this section of specifications and the applicable drawings and subject to the terms and conditions of the contract for the following work:

A. Air terminals and interconnecting conductors.

B. Grounding and bonding for lightning protection.

1.2 APPLICABLE SECTIONS

The General Conditions, Supplementary General Conditions, alternates and Addenda, applicable drawings and the technical specification including but not limited to the following;

A. Section “Electrical General Requirements”.

B. Section “Conductors and Cables”.

1.3 REFERENCES

A. LPI-175 - Lightning Protection Installation Standard.

B. LPI-176 - Lightning Protection System Material and Components Standard.

C. LPI-177 - Inspection Guide for LPI Certified Systems.

D. NFPA 78 - Lightning Protection Code.

E. UL 96 - Lightning Protection Components.

F. UL 96A - Installation Requirements for Lightning Protection Systems.

1.4 SYSTEM DESCRIPTION

A. Lightning Protection System: Conductor system protecting consisting of air terminals on roofs, roof-mounted mechanical equipment, chimneys and stacks, parapets, bonding of structure and other metal objects; grounding electrodes; and interconnecting conductors.

1.5 SUBMITTALS FOR REVIEW

A. Section 16 05 00 – Electrical General Requirements: Procedures for submittals.

B. Shop Drawings: Indicate layout of air terminals, grounding electrodes, and bonding connections to structure and other metal objects. Include terminal, electrode, and conductor sizes, and connection and termination details.

C. Product Data: Provide dimensions and materials of each component, and include indication of listing in accordance with UL 96.

1.6 PROJECT CLOSEOUT SUBMITTALS

A. Record actual locations of air terminals, grounding electrodes, bonding connections, and routing of system conductors in project record documents.

1.7 QUALITY ASSURANCE

A. Perform Work in accordance with NFPA 70.

B. Perform Work in accordance with UL 96A

C. Perform Work in accordance with LPI-175

1.8 QUALIFICATIONS

A. Manufacturer: Company specializing in lightning protection equipment with minimum three years experience and member of the Lightning Protection Institute.

B. Installer: Authorized installer of manufacturer with minimum three years experience and certified by the Lightning Protection Institute.

1.9 REGULATORY REQUIREMENTS

A. Product Listing: UL 96 and LPI-176.

B. System shall be UL listed and certified.

1.10 FIELD MEASUREMENTS

A. Verify that field measurements are as indicated on shop drawings.

1.11 COORDINATION

A. Coordinate work with roofing and exterior and interior finish installations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS AND INSTALLERS

A. VFC Corporation. North Salt Lake, Utah.

B. Robbins Lightning, Inc.

2.2 COMPONENTS

A. Air Terminals: Copper solid with adhesive bases for single-ply roof installations.

B. Air Terminal for Chimney: Lead-coated copper.

C. Grounding Rods: Solid copper

D. Ground Plate: Copper.

E. Conductors: Copper cable

F. Connectors and Splices: Bronze

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with NFPA 78, UL 96A and LPI-175.

B. Connect conductors using exothermic welding process. Protect adjacent construction elements and finishes from damage. All welds shall be witnessed by the OWNER.

C. Bond exterior metal bodies on building to lightning protection system and provide intermediate level interconnection loops 60 feet (18 m) on center.

3.2 FIELD QUALITY CONTROL

A. Obtain the services of Underwriters Laboratories, Inc. to provide inspection and labeling of the lightning protection system in accordance with UL 96A.

B. Obtain the services of the Lightning Protection Institute to provide inspection and certification of lightning protection system in accordance with LPI-177.

END OF SECTION

SECTION 16107
ELECTRICAL POWER SYSTEM STUDIES

PART 1 - GENERAL

1.1 SUMMARY

A. The electrical equipment manufacturer shall provide electrical power system studies for the project. The studies shall be prepared by the licensed professional electrical engineer of record for the plant. The type and content of each study is specified in the following articles.

1.2 SUBMITTALS

A. Completed electrical power system studies shall be bound and submitted to the ENGINEER.

1. Five (5) printed copies (hardcopies) of the completed study report shall be provided and one (1) copy in Microsoft Word or Adobe Acrobat format.
2. The software database and library used to model the power system shall be submitted in native file format including all updates to the library necessary to complete the model.

B. The CONTRACTOR shall attach brochures, resumes, references and other information indicating how your firm is qualified to provide the services outlined in this document.

C. The CONTRACTOR is responsible for compliance with all performance specifications in this proposal. Any deviation from complete compliance must be noted on the performance specification submitted for review and approved before work begins.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The analysis software shall be SKM Analysis Software or equal meeting all performance specifications.

2.2 ELECTRICAL POWER SYSTEM STUDIES

A. An electrical arc flash hazard analysis, including:

1. The development of an up-to-date electrical system one-line diagram and model to provide staff members with an accurate representation of the installed electrical system.
2. Determination of system operating modes and conditions that can impact short circuit currents and arc flash hazard energy levels.
3. Short circuit and equipment duty study to verify that equipment is rated to safely handle short circuit currents without creating hazardous conditions.
4. Protective device coordination study and review to help ensure proper electrical system reliability and to determine if arc flash hazard energy levels can be reduced.
5. Arc flash hazard analysis study to determine arc flash energy levels and Personal Protective Equipment (PPE).

6. Power System Modeling and Arc Flash Analysis software for ongoing use by the staff members maintaining and updating the system study as the plant changes.
7. Arc flash and safety program implementation software for ongoing use by the staff members for arc flash and safety program management and tracking.
8. Arc flash hazard labeling.
9. Assistance with the development of Energized Work Permits.
10. Arc flash and electrical safety training.
11. Personal Protective Equipment (PPE) training.

B. An electrical arc flash hazard analysis shall be performed to determine incident energy, arc flash protection boundaries, and required PPE for all electrical equipment in the facility. The calculations shall comply with NFPA-70E 2004, and IEEE-1584-2002. An integral part of NFPA-70E compliance is integrating work permits with arc flash assessment for all equipment in this facility. This section describes in detail the requirements for the study as well as integrating work permits in the system model for 70E compliance.

C. The purpose of this study is to provide a comprehensive software model of the electrical distribution system, which will document facility compliance with NFPA 70E mandates as described below. This model will serve as an integral part of an ongoing safety program by providing integral work permits and arc flash calculations in compliance with NFPA-70E 2004 Article 130.1(A)(2) for each electrical equipment in the facility.

1. Article 205.3, 120.2(F)(1): Updated and verified one-line diagram for all electrical distribution voltages including all sources for lock-out and tag out procedures.
2. Article 400.5, 400.6: Updated short circuit and equipment duty verification study showing all electrical equipment is properly rated to withstand and interrupt the available short circuit duty per ANSI Standards and NEMA/UL/NEC requirements.
3. Article 400.6, 410.9: Updated protective device coordination study showing the system protective devices are properly set to coordinate and clear a fault without extensive equipment damage or personnel risk.
4. Article 130.3(A)(B), 110.8: Updated arc flash study providing maximum incident energies, arc flash boundaries, and PPE requirements for each equipment in the system. In addition, these calculations shall be integrated with 70E compliant work permits as part of an ongoing safety program.
5. Article 130.16(E), 400.11, 400.14, 400.21(C)(2), 410.8: Updated labeling displaying the worst-case arc hazard values for each equipment in the facility.

D. The analysis shall consist of the following:

1. Field data collection by qualified personnel (as defined by NFPA 70E).
2. Data entry and system one-line modeling in commercially available power system software.
3. Model verification.
4. Short Circuit and equipment verification study.
5. Protective device coordination study.

6. Arc flash hazard study.
7. Detailed report and findings of the analysis.
8. Electronic copies of the Project Report and the System Modeling File.

E. The analysis and procedures shall comply with the following standards and recommended practices for power system studies.

1. NFPA-70E, 2004 Standard for Electrical Safety in the Workplace
2. IEEE-1584-2002
3. IEEE-242 “Buff Book” Protection and Coordination of Industrial Power Systems
4. IEEE-399 “Brown Book” Power System Analysis
5. IEEE-141 “Red Book” Electric Power Distribution for Industrial Plants

2.3 DATA COLLECTION

A. Field data collection shall be performed by qualified individuals (as defined by NFPA 70E – 2004) to ensure accurate equipment modeling.

B. Field data collection and system modeling shall be based on the system installed.

C. Equipment shall be visually inspected to collect the necessary nameplate data used in the analysis, including transformers, switchgear and breakers, relays, direct-acting trip units, etc. Data that may not be readily accessible or may not have nameplate data such as conductors, busway, etc. can be taken from drawings.

D. Data collection shall include the step down transformer from the utility service (including primary relaying) down through each 480-volt motor control center (MCC) and 240/208 volt panels for all systems served by transformers rated greater than 125 kVA as per IEEE-1584-2002.

E. The CONTRACTOR shall obtain from the utility the minimum, normal, and maximum operating service voltage levels, three-phase short circuit MVA and X/R ratio, as well as line-to-ground short circuit MVA and X/R ratio at the point of connection as shown on the drawings.

2.4 SYSTEM MODELING

A. The system model shall be developed using a commercially available, fully integrated software package that meets the performance specifications developed in this Section. To ensure compliance with NFPA-70E 2004, ANSI, and IEEE Standards, and OSHA mandates, no exceptions or substitutions to the performance specification are allowed.

B. The system model shall be laid out in one drawing/view and in a manner that provides for easy viewing of all analysis results. The one drawing/view requirement ensures that problem areas found and highlighted by the program are easily seen and not hidden or buried in multiple drawings, eliminating potential human errors where multiple drawing verification is required.

C. All one-line symbols shall be spaced properly to facilitate viewing results on the one-line.

D. Equipment names used in the modeling software shall be identical to the equipment and naming convention shown on the drawings and equipment unless conflicts exist. The CONTRACTOR shall bring all naming convention conflicts or deficiencies to the attention of the ENGINEER for clarification.

E. The facility may have multiple operating conditions, including, but not limited to, generation on/off, shutdown, bus-ties, start-up, emergency operation, etc. Each of the operating modes shall be documented and modeled in the software in order to determine the worst-case arc flash hazard and associated parameters for the electrical equipment. For the purpose, assume that up to four (4) operating modes are possible.

F. The software shall model each operating mode in a manner such that each mode is a scenario or change case from the base case. Each scenario shall be a simple differential algorithm storing only the difference from the base case and the scenario. Modifications to the base case model shall automatically update all scenarios to eliminate the necessity to store complete databases for each condition, providing for a manageable file size that can be Emailed and eliminating the associated time, man hours, and errors with updating each database individually.

G. Project files created by the software shall be single files and not project directories containing multiple files. The file shall be self-contained and have all necessary information to describe the one-line, system data, settings, and analysis information. Files shall be easily transferable to any site via Email or disk and operable with no setting changes to the database file to eliminate the maintenance and administrative problems associated with multi-file project directories, and to provide an easy method to transfer the file for engineering review.

H. The software shall accurately model daisy-chained MCC's, panels, and sub-transformers without the use of intermediate buses, nodes or fake impedances.

I. Lumped motor groups for MCC's shall be modeled per IEEE standards using groups >50 Hp, and <50 Hp. Where motor list data is not available, single lumped groups may be modeled per IEEE-141 "Red Book".

J. Medium voltage motors greater than 1.0 kV shall be modeled individually on their respective buses including all protective phase and ground overcurrent relays and fuses. This model will provide individual work permits for each starter/motor on the one-line.

K. All low voltage power circuit breaker (LVPCB), insulated case (ICCB), molded case (MCCB) and fuse data shall be modeled based on the actual nameplate data including manufacturer, type, style, trip device, and actual settings. Generic substitutions or assumptions shall not be allowed unless data cannot be field verified. All assumptions shall be documented in the report.

L. All relay data shall be modeled based on the actual nameplate data including manufacturer, type, style, trip device, and actual settings. Generic substitutions or assumptions shall not be allowed unless data cannot be field verified. All assumptions shall be documented in the report.

M. All overcurrent relay types for the distribution system shall be modeled on the one-line diagram (and database) including phase and ground overcurrent, differential, residual, ground neutral, etc. to establish a complete and detailed system model where protective device data can be easily modified and updated by the facility and all data is available for a comprehensive protective device coordination study if required in the future.

N. Relay models shall depict the actual connection requirements. See Figure-1.3M. Programs using symbols as shown in Figure-1.3M(na) are not acceptable since they do not depict the actual system and can lead to confusion in determining arc flash results and proper protective device modeling.

O. Multi-function relays shall have all their overcurrent devices modeled in a single device and shall be able to accept multiple CT's.

P. All equipment modeling must have a corresponding one-line diagram symbol. This means that there can be no hidden database models. The purpose is for the facility to easily see all equipment, its associated data, to be able to link documents to the equipment as a data repository, etc. and to see problems right on the one-line.

Q. All system modeling shall conform to accepted modeling practices as outlined in IEEE-399 "Brown Book". Contractor/consultant may provide more advanced modeling techniques where compliance with the specification is maintained.

2.5 MODEL VERIFICATION

A. The system model shall be verified by reviewing the results of short circuit current flows for all buses/equipment in the system. The results shall be viewed on each branch and total flow into a bus/equipment on the system one-line diagram. The purpose is to visually spot check values with recognized industry benchmarks as to the expected amount of short circuit current, and correct any problem areas.

2.6 SHORT CIRCUIT STUDY

A. A short circuit study shall be performed to verify all equipment duties in the system. The calculations shall comply with ANSI C37.010, C37.13, C37.5, IEEE-141, and IEEE-399. The short circuit study shall verify the system electrical equipment is properly rated to withstand and interrupt the expected bolted and arcing faults in the system. Improperly rated and applied equipment may not protect personnel against arc flash hazards even if properly applied PPE is used. The software program must comply with the above standards in order to properly verify equipment installed in North America. No substitutions will be allowed.

B. The equipment duty verification shall determine both the line side and load side fault current through each equipment and use the highest current to verify equipment ratings. Standard bus faults are not acceptable for protective devices in that they do not accurately model the current through the device and consequently they provide erroneous results. For solidly grounded systems, both three-phase and single-line-to-ground faults should be modeled. For other grounding configurations only a three-phase fault is required.

C. Equipment duty results shall be graphically displayed on the electrical one-line as well as tabular report format.

D. The results of the equipment duty verification tabular format report shall provide the following data:

1. Equipment name and kV
2. Manufacture, type, style, and ratings of the device
3. Actual line or load side currents through the device and percent over/under duty
4. Flag for the device showing VIOLATION or WARNING level for visual identification

E. A report of all problem areas shall be provided. Consultant/contractor shall notify XYZ Corporation – Abc Facility personnel immediately of all problems found in this system before proceeding in the study. A recommended action list shall be provided for all underrated equipment in the system.

2.7 PROTECTIVE DEVICE COORDINATION (PDC) STUDY

A. A PDC study shall be performed in order to determine if the system protection characteristics are sufficient to provide reliable power to the facility. The PDC study will also determine if the settings entered in the software will provide proper personnel protection in the arc flash portion of this study. For facilities where the main distribution is low voltage (under 600 volts) and only instantaneous breakers or fuses are used, this section may not apply.

B. The PDC study shall consist of system feeders and branch circuits 100amps and larger, and plotting the time-current curves (TCC's) to verify proper selective operation of the protective devices. The study should also determine if the settings can be enhanced to provide increased personnel/equipment protection without sacrificing selective coordination.

C. The CONTRACTOR shall notify the ENGINEER of any potential problems in the protective device settings that affect either selective operation and reliability or personnel protection and shall provide recommendations for changes in writing before continuing with the study.

D. As specified in the data collection and modeling sections, all PDC data shall be modeled on the one-line diagram and in the equipment database.

E. The CONTRACTOR shall contact the serving utility and obtain protective device settings for all service entrance over current devices in series with the facility and affecting coordination with facilities distribution system.

F. TCC Specifics: The TCC's shall graphically illustrate on log-log paper that adequate time separation exists between series devices. The specific time - current characteristics of each protective device shall be plotted in such a manner that sufficient upstream devices will be clearly depicted on one sheet to prove selective coordination.

1. TCC's shall include a system one-line diagram and protective device coordination curves for each device in the selected area. The TCC shall be printed in color on 8 ½ x 11" paper – full size portrait mode, using a log-log scale. The one-line diagram shall be part of the TCC and include all protective devices, equipment names, and short circuit currents calculated from the main one-line. The purpose of this requirement is to provide all necessary information on one sheet, in a format easily readable and standard to the industry.

2. For low voltage systems, TCC's shall be developed for both phase and ground protective devices. One phase and one ground TCC should be developed for each unit substation. The TCC should show the largest feeder/motor protective device in the MCC or panel up through the switchgear/switchboard feeder breaker, transformer secondary main, unit substation primary fuse, and medium voltage feeder breaker. For secondary switchboards serving large loads or a wide variety of loads that may affect upstream coordination, additional TCC's may be required.
3. For medium voltage systems, TCC's shall be developed for both phase and ground protective devices. The TCC should show the largest feeder/motor protective device in the lineup up through the switchgear/transformer secondary main, unit substation primary fuse, and medium voltage feeder breaker.

4. The following specific information shall also be shown on the coordination curves:
   a. Device identification.
   b. Voltage and current ratio for curves.
   c. Transformer three - phase and single-line-to-ground ANSI damage curves.
   d. Transformer inrush points.
   e. Minimum melting, and clearing curves for fuses, and if available the no-damage curve.
   f. Cable damage curves.
   g. Motor starting locked rotor curves, and if available the motor locked rotor damage point.
   h. Maximum short circuit cut-off point.
   i. Clearly marked short circuit current levels through each protective device/branch, which should be based on the appropriate current through the device, i.e. Momentary, Interrupting or 30 Cycle current.
   j. Protective device one-line diagram clearly showing all protective devices on the time-current curve, labels for each device, open breakers, faulted buses, and the short circuit current flowing in each branch.
   k. Each TCC sheet shall have appropriate identification and a one-line diagram that applies to the specific portion of the system associated with time-current curves on that sheet.
   l. Each protective device curve shall be terminated at a point reflecting maximum symmetrical or asymmetrical fault current through the device.
   m. Identify the device associated with each curve by manufacturer type, function, and setting – i.e. tap, time delay, and instantaneous, pickup, etc.
   n. Primary Protective Device Settings for Delta-Wye Connected Transformer:
      1) Secondary Line-To-Ground Fault Protection: Provide primary protective device operating band within the transformer's characteristics curve, including a point equal to 58 percent of ANSI C57.12.00 withstand point.
      2) Secondary Line-To-Line Faults: Provide 16 percent current margin between primary protective device and associated secondary device characteristic curves.

o. Typical time separations for curves:

1) Consultant/contractor shall discuss the advantages and disadvantages of various time separation settings between device curves with XYZ Corporation – Abc Facility personnel to help determine how the system settings shall be optimized for selectivity and arc flash hazard reduction.

G. A setting table shall be developed to summarize the settings selected/existing for the protective devices. The table shall include the following:

1. Device identification.
2. For low voltage breakers, the circuit breaker manufacturer, type, and style, sensor rating, long-time, short-time, instantaneous settings, and time bands. For breakers with ground fault capability, the pickup and time delay.
3. Fuse manufacturer, type, style, and rating.
4. Protective relay manufacturer, type, style, function (51, 50, 67, etc.) pickup, current multiplier, time dial, and delay. For multi-function units, list all devices being used. Include the CT and/or PT ratios for each function.

H. The software shall provide complete integration of the one-line, database, short circuit, protective device coordination and arc flash analysis functions to provide accurate calculations and avoid errors and inefficiencies associated with multiple data entry programs. Programs using separate PDC or TCC plotting packages are not allowed. Complete PDC integration is defined as the following:

1. TCC's shall be developed by simply selecting (highlighting) with the mouse the one-line area to be coordinated. The TCC shall automatically be plotted for the selected area including all short circuit levels. The TCC plot shall automatically include the selected one-line area in a drag and drop window on the TCC showing all one-line attributes without user additions required. These attributes shall automatically include all short circuit currents and voltages displayed on the main one-line, equipment names, etc. and update automatically without additional user input.
2. Programs requiring the user to build a separate TCC one-line are not integral with system short circuit calculations and do not automatically update as the system one-line changes, requiring additional man-hours for one-line development and are consequently prone to errors as the system changes. These types of programs shall not be considered for the study.
3. Each TCC shall have momentary (1/2 cycle), interrupting (1-4 cycle), and 30 cycle short circuit currents (tick marks) displayed on the TCC plot for each protective device or as required to properly model the tripping characteristics of the device. The tick marks shall be user adjustable for visual appearance. The purpose is to provide accurate tripping currents for each device.
4. The software model shall allow each protective device to model momentary (1/2 cycle), interrupting (1-4 cycle), and 30 cycle short circuit currents simultaneously depending on the characteristics of the device.

5. The software shall model remote voltages and currents for any single fault and display them on the TCC showing all trip cutoffs based on the remote currents. The purpose is to accurately model and verify backup relaying to ensure selective operation under all fault conditions. PDC programs that perform only batch faults, or fail to model remote voltages and currents for all fault types shall not be considered.
6. The software shall model and display time difference calculations for any selected pair of protective devices. The difference calculator shall include bracketing bars with the calculated difference to clearly show the selective time between the devices. The calculated time shall update dynamically for instant visual setting as the devices are dragged (settings modified). In addition, Windows tool tips shall clearly show the time difference and the protective device settings for all devices as they are dynamically changed or set to allow the user to accurately determine the proper setting between devices in the most efficient manner, reducing coordination time and providing more accurate results.
7. The software model shall provide for WYSIWYG drag and drop modeling of all protective devices and provide for tool tips and notes to display all settings dynamically. The purpose is to provide accurate adjustments and settings in the most time efficient and accurate manner.
8. TCC's shall have the ability to display short circuit currents and arc flash hazard results within the fully integrated system one-line in the PDC focus. Short circuit currents are available at any equipment with a single mouse click. Short circuit currents and arc flash hazard values shall change on the fly as the protective device settings change, allowing the user to instantly see the results of PDC changes and the associated impact to short circuit currents and arc flash hazard values.
9. The software model shall provide a detailed library for the most common protective devices available in North America. The library shall be user definable.

2.8 ARC FLASH STUDY

A. A detailed arc flash study shall be performed to determine potential arc flash incident energies, arc flash boundaries, shock hazard boundaries and proper personal protective equipment (PPE) for all energized electrical system equipment tasks for the electrical system studied. The calculations shall comply with NFPA-70E 2004, and IEEE-1584. Bolted short circuit calculations used in the above standards shall comply with ANSI C37.010, C37.13, C37.5, IEEE-141, and IEEE-399. The purpose of this study is to determine arc flash hazards in conformance with NFPA-70E and to facilitate a safety program for the OWNER, and to provide a comprehensive software model of the electrical distribution system, which provides integral work permits and arc flash calculations in compliance with NFPA 70E Article 130.1(A)(2) for all equipment in the facility. The software program used in this study shall comply with the above standards. No substitutions in calculation methods will be allowed.

B. The arc flash study shall determine the following results for each system mode of operation. The results shall be provided in spreadsheet format for each mode and electrical system location to provide easy viewing and comparison. Worst-case arc flash energy levels shall be flagged and the spreadsheet comparison table shall be capable of providing its output directly to high quality vinyl label printers. The calculations shall, as a minimum, include a comparison of both 100% and 85% arcing currents for low voltage equipment for each electrical system configuration or operating mode, indicating worst-case arc flash hazards. The spreadsheet results shall include:

1. Equipment name and voltage.
2. Upstream equipment device name and ANSI function, i.e. 51/50, etc.
3. Equipment type, i.e. switchgear, MCC, Panel, VFD, etc.
4. Equipment arc gap.
5. Bolted and estimated arcing fault current at the fault point (equipment) in symmetrical amperes. The estimated arcing current should be based on the arcing current equations used.
6. Trip time, opening time, and total clearing time (total Arc time) of the protective device.
7. Worst-case arc flash boundary for each bus/equipment in the model.
8. Worst-case arc flash hazard incident energy in cal/cm^2 for each bus/equipment in the model.
9. Worst-case personal protective equipment (PPE) for each bus/equipment in the model.
10. Working distances for up to five different distances showing items 7, 8, and 9 for each distance.
11. Indicate "Danger/Hazardous" areas where incident energy is greater than 40 cal/cm^2 and provide recommendations to reduced arc flash energy levels for these areas.
12. Flag results where 85% arcing current provided worst-case results.

C. Each mode of operation shall include a detailed write-up indicating areas where incident energy calculations and PPE requirements are higher than calculated in the normal operating mode.

D. Consultant/contractor shall provide a detailed arc flash analysis report including as a minimum:

1. Introduction.
2. Methodology.
3. Information Sources.
4. Key Assumptions.
5. Arc Flash Energy and other consideration for various System Modes of Operation (maintenance mode, bus-tie, co-gen on/off, etc.).
6. Arc Energy at 100% and reduced currents.
7. IEEE 1584-2002 Considerations.

8. Overcurrent Protective Device Changes, Replacements or Setting Changes implemented in study to reduce arc flash hazard exposure.
9. Explanation of Data in Arc Flash Hazard Report Tables.
10. NFPA 70E Information.
    a. Shock Hazards with covers removed.
    b. Shock Hazard Approach Boundaries.
        1) Limited Approach Boundary.
        2) Restricted Approach Boundary.
        3) Prohibited Approach Boundary.
    c. Arc Flash Hazard Boundaries.
11. Results of Arc flash Hazard Analysis for high voltage, medium voltage and low voltage systems, including:
    a. Working distances.
    b. Energy Levels.
    c. PPE Requirements.
    d. Recommendations to reduce arc flash hazard energy and exposure.
12. Arc Flash Hazard Report.
    a. 5 Hard Copies.
    b. 1 Electronic Copy in Adobe Acrobat format (5.0 or later).
13. Electronic file for Power System Modeling Software as developed and utilized for this analysis.

E. The CONTRACTOR shall provide printed labels for labels for all equipment in the system from the project study file. Assume three (3) labels per equipment/bus in your estimate using 4" x 6" labels or one (1) 6" x 8" label per equipment bus. The labels shall be UV resistant vinyl labels (white with orange warning strip and black letters) conforming to ANSI-Z535. The labels shall be printable directly from the power system software utilized for the study with a Duralabel, Brady PowerMark or GlobalMark printer to ensure that the OWNER's personnel have the option of printing the labels without the extra expense of going to an outside printing service, converting arc flash results to spreadsheet format or performing tedious manual data entry.

F. Software Requirements: The software shall provide complete integration of the one-line, database, short circuit, PDC and Arc flash functions. Software using separate short circuit, PDC, TCC or arc flash programs is not allowed. Spreadsheet calculations are not allowed. The purpose of this section is to ensure that the arc flash hazard calculations comply with NFPA-70E and IEEE-1584, and that the calculations are programmed with necessary requirements to help eliminate possible errors in the arc flash calculations. The additional purpose is to establish a detailed software model of the XYZ Corporation – Abc Facility electrical distribution system, which will document compliance with the OSHA requirements and NFPA 70E mandates. This model will serve as an integral part of the OWNER's safety program by providing integral work permits and arc flash calculations in compliance with NFPA-70E Article 130.1(A)(2) for each electrical equipment in the facility.

1. Arc flash calculations shall be performed with enhanced IEEE-1584 equations, which eliminate voltage discontinuities and the non-conservative/average results of the standard equations. The purpose of this requirement is to ensure that the calculated incident energies are closer to actual test results insuring a conservative calculation minimizing personnel risk.

2. Arc flash calculations shall be based on the fastest clearing upstream protective device protecting the equipment for single sources and the slowest upstream protective device for multiple sources. The calculations shall automatically compare all series and parallel upstream protective devices in the system to determine the fastest series device or a conservative parallel clearing time. The algorithm shall incorporate a traversing routine that can search back an unlimited number of buses/nodes and consider all series and parallel branches in the comparison to ensure accurate answers and to prevent hazards associated with incorrect results. Software <u>shall not</u> have trace back limits (5-10 buses) that can provide incorrect answers for low voltage faults that require high voltage protective device clearing to prevent potential errors.

3. The arc flash calculations including arc flash boundary, incident energy, PPE requirements, and working distance shall be displayed on the software one-line diagram and TCC simultaneously. The software must show visually the arc flash values as the settings are incrementally changed (dragging curves) so the protection can be optimized in the most efficient manner, allowing the protection engineer to visually balance the competing objectives of personnel protection with that of system selectivity.

4. The arc flash calculations shall include four (4) calculation options to ensure that the software provides the flexibility required to meet any system configuration or training requirement that may be considered. Each calculation option shall comply with the graphic and spreadsheet display requirements of this section. Each option is more specifically described below.

    a. The detailed option shall provide the let-through energy for each protective device in the system. This is the energy on the load side of the protective device. The equipment shall be highlighted when the let-through energy exceeds a user defined threshold-clothing limit.

b. Worst-case including main protective device. This option shall provide the worst-case arc-hazard energy for the equipment based on the let-through energy of the equipment's main protective device. If the equipment is not equipped with a main device, the program must traverse back the entire system to determine the fastest series upstream protective device. The equipment shall be highlighted when the let-through energy exceeds a user defined threshold-clothing limit.

c. Worst-case excluding main protective device. This option shall provide the worst-case arc-hazard energy for the equipment based on the let-through energy of the fastest upstream series protective device in the system. The program shall traverse back the entire system to determine the fastest upstream protective device. The equipment shall be highlighted when the let-through energy exceeds a user defined threshold-clothing limit.

d. Worst-case excluding and including the main protective device. A combination of options 'b' and 'c' as stated above.

5. The arc flash calculations shall provide integral "Work Tasks" for the listed equipment types. The tasks shall be derived from 70E Table 130.7(C)(9)(a) and be specific to the equipment type. Work tasks shall be user definable in the software to allow customization and integral with the "Work Permit" feature of the software. Listed equipment types shall include:

   a. Switchgear, Switchboards, Panelboards, MCC, VFD, UPS, ATS, Interrupting Switch, NEMA E2 Contactor, Conductor, Open Air for 100-200 volt equipment.

   b. Switchgear, Switchboards, Panelboards, MCC, VFD, UPS, ATS, Interrupting Switch, NEMA E2 Contactor, Conductor, Open Air for 200-1000 volt equipment.

   c. Switchgear, MCC, VFD, UPS, ATS, Interrupting Switch, NEMA E2 Contactor, Conductor, Open Air for 1.0-5.0 kV equipment.

   d. Switchgear, MCC, VFD, ATS, Interrupting Switch, NEMA E2 Contactor, Conductor, Open Air for 5.0-15.0 kV equipment.

   e. Switchgear, Interrupting Switch, Conductor, Open Air for 15.0-38.0 kV equipment.

   f. Interrupting Switch, Conductor, and Open Air for 38.0-1500 kV equipment.

6. Work Tasks shall have a user-defined library that provides the following customizable features for each work task:

   a. Work Tasks for each specific equipment type and voltage range.

   b. Working distance units English or Metric.

   c. Work distance for each task.

   d. V-rated gloves and tool requirements.

   e. Job description and procedures.

   f. Safe work practices description.

   g. Hazard Risk Category (HRC) reduction. *Note: HRC reduction can only be used based on a documented risk assessment as an integral part of a safety program.

7. Work tasks shall be accessible from the one-line diagram for any equipment through a mouse click on the equipment in the electrical system model one-line. A dialog box shall appear listing all 70E and user definable work tasks for the specific equipment selected. The work task dialog shall include a user definable working distance for each work task and allow the user to select tasks specific to any equipment feeder or the incoming main. Work tasks for each equipment type shall be voltage specific and user definable in the library. The purpose of these requirements is to integrate 70E work tasks to the one-line diagram for specific equipment types. This will provide the basis for a customized safety program and work permit process compliant with 70E mandates. The level of detailed requirements for the "work task" software is necessary to ensure that any variation of equipment type, equipment layout, or work procedure can be handled and documented in the software.
   a. The software interface shall allow the user to select any breaker fuse or switch on the one-line, and get a specific work task generated for that device showing the load side arc flash hazard (let-through energy) for that device. The purpose of this requirement is to detail specific feeder hazards when work tasks dictate working downstream from a feeder protective device.
   b. The arc flash calculations shall provide integral work permits for compliance with NFPA-70E, 2004 Article 130.1 (A). The work permits shall be integral with the system one-line diagram and the arc flash calculations and shall detect and account for work between feeder and main breaker.
8. Work permits shall be activated by mouse click, for all equipment types listed in K5. Work permits shall have the following calculated values and provide the following information specific to the "work task" and equipment selected:
   a. Shock hazard.
   b. Shock hazard boundaries.
   c. Arc flash boundary – worst-case for each equipment.
   d. Arc flash hazard incident energy in cal/cm2 for the equipment.
   e. Hazard Risk Category (HRC) and any applicable risk reduction.
   f. Required PPE category based on calculated energy level and optional risk reduction.
   g. Required PPE description based on PPE category.
   h. Determination of V-rated gloves and tools.
   i. Auto fill job description and procedures for each work task.
   j. Auto fill safe work practices description for each work task.
   k. Job briefing and planning check list.
   l. Approval sign off section.
   m. Working distance measurements in English or Metric units.
   n. Required work distance for each task.
   o. Documentation for safety program in compliance with 70E 130.1(A).
9. The work permits shall be created by the software in MS Word and have the following user customizable features:

a. Work Tasks for each specific equipment type and voltage range.
b. Restricted shock boundary.
c. Arc flash boundary – worst-case for each equipment.
d. Arc flash hazard incident energy in cal/cm2 for the equipment.
e. Hazard Risk Category (HRC) reduction for low risk tasks.
f. Required PPE category based on risk reduction.
g. Working distance in English or Metric units.
h. Working distance for each task.
i. V-rated gloves and tool requirements.
j. Flame Resistant clothing requirements.
k. Job description and procedures for each work task.
l. Safe work practices description for each work task.
m. Job briefing and planning check list.
n. Approval sign off section.

10. The power system software shall allow the created work permits to be linked via Windows "hyperlinks" to each equipment on the one-line diagram. The purpose is to provide a data repository of work permits performed on each equipment for 70E review, as well as providing a one-stop location where documents pertaining to the equipment can be accessed by maintenance and job planning.

11. The power system software shall be fully compatible with facility arc flash hazard and electrical safety implementation software that provides the following capabilities:

    a. Calculates shock hazards, shock hazard boundaries, arc flash boundaries, incident energies, PPE requirements, etc. for power systems modeled in EasyPower or EasyPower EasySolv.

    b. Built in Work Permit Feature for creation of custom Energized Work Permits complying with the NFPA-70E requirements. Work permit feature shall include NFPA risk assessment categories based on the task performed for all types of electrical equipment and voltage ranges. The work permit feature shall include an extensive library of user definable work tasks, safety procedures and safe work practices, saving XYZ Corporation – Abc Facility plant engineering staff, maintenance staff and contractors hours of productive time.

    c. Energized work permits, safety procedures, equipment instruction manuals, etc., shall be capable of being directly linked to the equipment one-line through a Hyperlinks feature, providing a one-stop data repository easily accessible to all plant and safety personnel, saving plant personnel and contractors significant productive time in locating the right instruction manual, equipment safety procedure, drawing, pictures and maps for the equipment. This feature shall also help XYZ Corporation – Abc Facility comply with OSHA and NFPA 70E record keeping requirements.

    d. Additional equipment information and records such as Maintenance Records, Maintenance Manuals, Operations Manuals, Lock out / Tag out procedures, etc. shall also be capable of being Hyperlinked to the equipment on the graphical one-line.

e. Program shall support creation of arc flash labels with direct output to high quality UV resistant vinyl label printers.

f. Program shall also have customizable output. Includes one-line printing, text report creation, export to AutoCAD, etc.

g. Program shall be a Windows based operating system and shall use Windows conventions.

h. Program shall be capable of being installed on stand alone personal computers or on networked systems and shall be compatible with all systems operating on Windows 2000 or higher operating systems.

i. Program shall be easily operable by the OWNER's staff without any specialized training.

12. The software shall be licensed to the OWNER and the original software package will be delivered at project completion.

2.9 REPORTING AND ANALYSIS SUMMARY

A. Executive Summary: The executive summary shall be brief 1-2 pages maximum and cover at an executive level the findings of the study, recommendations, and requirements for maintaining NFPA-70E compliance.

B. Scope of studies performed: The scope shall provide details of what actions were intended to be performed for each aspect of the study, including short circuit, protective device coordination, and arc flash.

C. Description of system and explanation of bus and branch numbering system.

D. Modes of operation studied: Each scenario/plant operating condition shall be thoroughly documented.

E. Detailed report and results of short circuit, coordination, and arc flash studies including:

1. Recommendations and additions to equipment rating and/or PDC characteristics.
2. Recommendations to reduce arc flash hazards for equipment with incident energies over 40 cal/cm^2.

F. Prioritized recommendations for all studies.

G. Action list and check off column for all recommendations.

2.10 QUALITY ASSURANCE

A. The studies shall be in conformance with the NFPA and ANSI Standards, and IEEE recommended practices detailed in this section. No substitutions in study methods or software conformance will be allowed.

END OF SECTION

SECTION 16108
ELECTRICAL ACCEPTANCE TESTS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This section covers the work necessary to provide the inspection and testing services required to place the electrical system into operation.

1.2 GENERAL

A. See General Conditions and Division 1, GENERAL REQUIREMENTS, which contain information and requirements that apply to the work specified herein and are mandatory for this project.

B. This work may be conducted by the electrical subcontractors and/or independent testing laboratory but shall be performed by qualified personnel. The decision concerning acceptability of the qualifications of the individual and/or firm conducting the tests shall be determined during submittal review in accordance with Section “Quality Control”. The term "testing laboratory" shall unilaterally refer to the firm, subcontractor, etc., approved to conduct the tests.

1. For the purposes of the section the individual performing the testing, whether the electrical subcontractor, manufacturer's representatives or independent testing laboratory, shall be referred to as "testing laboratory."
2. The Contractor shall submit a division of responsibilities that shall detail who is responsible for performing each test.
3. All visual and mechanical inspections shall be conducted by the Contractor and Engineer.

C. The testing laboratory shall provide all material, equipment power, labor and technical supervision to perform such tests and inspections.

D. It is the intent of these tests to assure that all electrical equipment is operational within industry and manufacturer's tolerances.

E. Upon completion of the tests and inspections noted in these specifications, a label shall be attached to all serviced devices. These labels will indicate date serviced and the service company responsible.

F. The tests and inspections shall determine suitability for continued reliable operation.

G. All tests shall be conducted in the presence of the Engineer.

H. Electrical testing specified herein, and functional testing of all power and controls not tested under the Section “Process Control and Instrumentation Systems”, shall be completed before commencement of the 7-day test specified in Section “Electrical Acceptance Tests”.

I. The work may require the Contractor to activate circuits, shutdown circuits and run equipment, make electrical measurements, replace blown fuses, install temporary jumpers, etc.

J. Specific scope of work:

1. The following items of equipment shall be tested:
   a. Low voltage switchgear
   b. Motor control centers
   c. Transformers
   d. All wires and cables
   e. Motors
   f. Regulators
   g. Grounding system
   h. Entire control system and all process interfaces
   i. Adjustable speed drive (ASD) systems
   j. Reclosers
   k. Switches
   l. Lighting
2. All inspections and tests shall utilize the following references:
   a. Project design specifications
   b. Project design drawings
   c. Manufacturer's instruction manuals applicable to each particular apparatus.

K. Division of responsibility:

1. The Contractor shall perform routing insulation resistance, continuity and rotation tests for all distribution and utilization equipment prior and in addition to tests performed by the testing laboratory specified herein.
2. The Contractor shall supply a suitable and stable source of test power to the test laboratory at each test site. The testing laboratory shall specify requirements.
3. The Contractor shall notify the testing laboratory and schedule with the Engineer when equipment becomes available for acceptance tests.
4. The Contractor shall notify the Engineer prior to commencement of any testing.
5. The testing laboratory shall be responsible for implementing all final settings and adjustments on protective devices and tap changes in accordance with Owner's specified values.
6. Any system material or workmanship which is found defective on the basis of acceptance tests shall be reported directly to the Engineer.
7. The testing laboratory shall maintain a written record of all tests and upon completion of project, assemble and certify a final test report.

1.3 REFERENCED STANDARDS

A. See Section “General Electrical Requirements”, which lists the standards that apply to the work specified herein.

B. In addition, the following shall apply:

1. Manufacturer's recommended tests
2. ANSI C2, C37.20.1
3. NEMA WC 7, WC 8
4. IEEE 43,48,81,118
5. NETA ATS
6. NFPA 70

1.4 SUBMITTALS DURING CONSTRUCTION

A. Submittals during construction shall be made in accordance with Division 1, GENERAL REQUIREMENTS and Section “General Electrical Requirements”.

B. In addition, the following information shall be provided:

1. Shop drawings:
   a. The testing laboratory shall submit, in conformance with Section “Contractor Submittals”, a complete resume and statement of qualifications detailing their experiences in performing the test specified. This statement shall include:
      1) Corporate history and references.
      2) Resume of individual performing test.
      3) Equipment list and test calibration data.
   b. The Contractor shall submit to the Engineer and the testing laboratory, in conformance with Section “Contractor Submittals”, complete manufacturer's field testing acceptance testing procedures, as well as expected test results and tolerances for all equipment to be tested.
      1) Administrative Submittals: Submit 30 days prior to performing inspection or tests:
      2) Schedule for performing inspection and tests.
      3) List of references to be used for each test.
      4) Sample copy of equipment and materials inspection form(s).
      5) Sample copy of individual device test form.
      6) Sample copy of individual system test form.
      7) Quality Control Submittals: Submit within 15 days after completion of test: Test or inspection reports and certificates for each electrical item tested.
      8) Contract Closeout Submittals:

a) Operation and Maintenance Data:

b) In accordance with Section “Operation and Maintenance Data”.

c) After test or inspection reports have been reviewed by Engineer and returned, insert a copy of each in Operation and Maintenance Manual.

2. Test Report:

a. The test report shall include the following:

1) Summary of project.

2) Description of equipment tested.

3) Description of test.

4) Test results.

5) Conclusions and recommendations.

6) Appendix, including appropriate test forms.

7) List of test equipment used and calibration date.

b. Furnish six (6) copies of the completed report to the Engineer in conformance with Section “Contractor Submittals”.

PART 2 - PRODUCTS

2.1 TEST INSTRUMENT TRACEABILITY

A. The testing laboratory shall have a calibration program which maintains all applicable test instrumentation within rated accuracy.

B. The accuracy shall be traceable to the National Bureau of Standards in an unbroken chain.

C. Instruments shall be calibrated in accordance with the following frequency schedule.

1. Field instruments - 6 months maximum.
2. Laboratory instruments - 12 months.
3. Leased specialty equipment - 12 months. (Where accuracy is guaranteed by lessor).

D. Dated calibration labels shall be visible on all test equipment.

E. Records must be kept up-to-date which show date and results of all instruments calibrated or tested.

F. An up-to-date instrument calibration instruction and procedure will be maintained for each test instrument.

PART 3 - EXECUTION

3.1 PREPARATION

A. Safety and Precautions:

1. Safety practices shall include, but are not limited to the following requirements:
   a. Occupational Safety and Health Act - OSHA
   b. Accident Prevention Manual for Industrial Operations, Seventh Edition, National Safety Council, Chapter 4.
   c. Applicable State and Local safety operating procedures.
   d. NETA Safety/Accident Prevention Program.
   e. National Fire Protection Association - NFPA 70E.
2. The testing laboratory shall be solely responsible for safety during all tests.
3. In all cases, work shall not proceed until the testing laboratory, Contractor, and Engineer determine that it is safe to do so.
4. The testing laboratory shall have available sufficient protective barriers and warning signs to conduct specified tests safety.

B. Testing requirements prior to commencing the work:
1. All instruments required must be available and in proper operating conditions.
2. All dispensable materials such as solvents, rags and brushes required must be provided.
3. All equipment handling devices such as cranes, vehicles, chain falls and other lifting equipment must be available or scheduled.
4. All instruction books, calibration curves or other printed material to cover the electrical devices must be available.
5. Data sheets to record all test results must be available before the work is started.

C. Tests and inspection shall establish that:
1. Electrical equipment is operational within industry and manufacturer's tolerances.
2. Installation operates properly.
3. Equipment is suitable to be energized.
4. Installation conforms to requirements of these specifications and NFPA 70, NFPA 70E, and ANSI C2.

D. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer's recommendations.

E. Adjust all mechanisms and moving parts for free mechanical movement.

F. Adjust all adjustable relays and sensors to correspond to operating conditions, or as recommended by manufacturer.

G. Verify nameplate data for conformance with these specifications.

H. Realign equipment not properly aligned and correct any unevenness.

I. Properly anchor electrical equipment found to be inadequately anchored.

J. Tighten all accessible bolted connections, including wiring connections, with calibrated torque wrench to manufacturer's recommendations, or otherwise specified.

K. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.

L. Provide proper lubrication of all applicable moving parts.

M. Inform Engineer of any working clearances not in accordance with NFPA 70.

N. Investigate and repair or replace:

1. Electrical items that fail tests.
2. Active components not operating in accordance with manufacturer's instructions.
3. Damaged electrical equipment.

O. Electrical enclosures:

1. Remove foreign material and moisture from enclosure interior.
2. Vacuum and wipe clean enclosure interior.
3. Remove corrosion found on metal surfaces.
4. Repair or replace, as determined by the Engineer, door and/or panel sections having dented surfaces.
5. Repair or replace, as determined by the Engineer, poor-fitting doors and/or panel sections.
6. Repair or replace improperly operating latching, locking, or interlocking devices.
7. Replace missing or damaged hardware.
8. Finish:
   a. Provide matching paint and touch-up scratches and mars.
   b. If required due to extensive damage, as determined by the Engineer, refinish the entire assembly.

P. Replace fuses and circuit breakers that do not conform to size and type required by these specifications.

Q. Replace transformer insulating oil not in compliance with ASTM D923.

3.2 QUALITY ASSURANCE

A. Testing Firm's Qualifications:

1. Corporately and financially independent organization which can function as an unbiased testing authority.
2. Professionally independent of manufacturers, suppliers, and installers of electrical equipment and systems being tested.
3. Employer of engineers and technicians regularly engaged in testing and inspecting of electrical equipment, installations, and systems.
4. Supervising engineer accredited as Certified Electrical Test Technologist by National Institute for Certification of Engineering Technologies (NICET), or International electrical Testing Association and having a minimum of five (5) years testing experience on similar projects.
5. Technicians certified by NICET or NETA.
6. Assistants and apprentices assigned to project at ratio not to exceed two (2) certified to one (1) noncertified assistant or apprentice.

7. Registered Professional Engineer to provide comprehensive project report outlining services performed, results of such services, recommendations, actions taken, and opinions.
8. In compliance with OSHA 29 CFR Part 1907, "Criteria for Accreditation of Testing Laboratories," or a full-member company of the International Electrical Testing Association.
9. Test equipment shall have an operating accuracy equal to, or greater than, requirements established by NETA ATS.

B. Test instrument calibration shall be in accordance with NETA ATS.

3.3 SEQUENCING AND SCHEDULING

A. Perform inspection and electrical tests after equipment has been installed.

B. Perform tests with apparatus de-energized whenever feasible.

C. Inspection and electrical tests on energized equipment are to be:
1. Scheduled with Engineer prior to de-energization.
2. Minimized to avoid extended period of interruption to the operating plant equipment.

D. Notify Engineer at least 24 hours prior to performing any tests on energized electrical equipment.

3.4 INSPECTION AND TEST PROCEDURES

A. Switchgear Assembly:
1. Visual and mechanical inspection for:
   a. Physical damage
   b. Equipment nameplate information conformance with latest single line diagram and report discrepancies.
   c. Proper alignment, anchorage and grounding.
   d. Tightness of accessible bolted bus joints by calibrated torque wrench method. Refer to manufacturer's instruction for proper foot pound levels.
   e. Paint chips, dents, scratches, etc.
   f. Insulator damage and contaminated surfaces.
   g. Proper barrier and shutter installation and operation.
   h. Proper operation of indicating devices.
   i. Improper blockage of air cooling passages.
   j. Integrity and contamination of bus insulation system.
   k. Check nameplates for proper identification of:
      1) Equipment title and tag number with latest one-line diagram.
      2) Pushbuttons.
      3) Control switches.
      4) Pilot lights.

5) Control relays.

6) Circuit breakers.

7) Indicating meters.

l. Verify that fuse and/or circuit breaker ratings, sizes, and types conform to those specified.

m. Check bus and cable connections for high resistance by low resistance ohmmeter and calibrated torque wrench applied to bolted joints.

1) Ohmic value to be zero.

2) Bolt torque level in accordance with NETA ATS, Table 10.1, unless otherwise specified by manufacturer.

n. Check operation and sequencing of electrical and mechanical interlock systems by:

1) Closure attempt for locked open devices.

2) Opening attempt for locked closed devices.

3) Key exchange to operate devices in off-normal positions.

o. Verify performance of each control device and feature.

p. Control wiring:

1) Compare wiring to local and remote control and protective devices with elementary diagrams.

2) Proper conductor lacing and bundling.

3) Proper conductor identification.

4) Proper conductor logs and connections.

q. Exercise all active components.

r. Perform phasing check on double-ended equipment to ensure proper bus phasing from each source.

2. Electrical tests:

a. Insulation resistance test:

1) Applied megohmmeter dc voltage in accordance with NETA ATS, Table 7. 1. 1.

2) Each phase of each bus section.

3) Phase-to-phase and phase-to-ground for I minute.

4) With switches and breakers open.

5) With switches and breakers closed.

6) Control wiring except that connected to solid state components.

7) Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.

b. Overpotential test:

1) Applied voltage and test procedure in accordance with ANSIC37.20.1.

2) Each phase of each bus section.

3) Phase-to-phase and phase-to-ground for I minute.

4) Test results evaluated on a pass-fail basis.

c. Current injection tests:

1) For entire current circuit in each section.

2) Secondary injection for current flow of I ampere.

3) Test current at each device.

d. Control wiring:

1) Apply secondary voltage to all control power and potential circuits.

2) Check voltage levels at each point on terminal boards and each device terminal.

e. Operational test:

1) Initiate all control devices.

2) Check proper operation of control system in each section.

3. Test values:

a. Bolt torque levels shall be in accordance with values specified by manufacturer.

b. Insulation resistance test to be performed in accordance with manufacturer's specified values.

B. Grounding Systems:

1. Visual and mechanical inspection for:

a. Compliance with plans and specifications.

b. Equipment and circuit grounds in motor control centers, panelboards, switchgear, and motors for proper connection and tightness.

c. Ground bus connections in motor control centers, panelboards, switchgear, and control panels for proper termination and tightness.

d. Effective transformer core and equipment grounding.

e. Accessible connections to grounding electrodes for proper fit and tightness.

f. Accessible exothermic-weld grounding connections to verify that molds were fully filled and proper bonding was obtained.

2. Electrical tests:

a. Perform fall of potential test per IEEE Standard No. 81, Section 9.04 on the main grounding electrode or system.

b. Perform the two (2) point method test per IEEE No. 8 1, Section 9.03 to determine the ground resistance between the main grounding system and all major electrical equipment frames, system neutral and/or derived neutral points. Equipment ground resistance shall not exceed main ground system resistance by 0.25 ohms.

c. Alternate method: Perform ground continuity test between main ground system and equipment frame, system neutral and/or derived neutral point. This test shall be made by passing a minimum of test (IO) amperes D.C. current between ground reference system and the ground point to be tested. Voltage drop shall be measured and resistance calculated by voltage drop method.

3. Test values: The main ground electrode system resistance to ground should be no greater than one (1) ohm.

C. Low Voltage Cables - 600 Volts and Below:

1. Visual and mechanical inspection for:

a. Physical damage and proper connection in accordance with single line diagram.

b. Equipment nameplate data compliance with design plans or starter schedule.

c. Overload heaters compliance with motor full load current for proper size.

d. Tightness of bolted connections.

e. Proper barrier and shutter installation and operation.

f. Proper operation of indicating and monitoring devices.

g. Proper overload protection for each motor.

h. Improper blockage of air cooling passages.

i. Proper operation of any draw out elements.

j. Integrity and contamination of bus insulation system.

k. Check door and device interlocking system by:

1) Closure attempt of device when door is in OPEN position.

2) Opening attempt of door when device is in ON or CLOSED position.

l. Check nameplates for proper identification of:

1) Equipment title and tag number with latest one-line diagram.

2) Pushbuttons.

3) Control switches.

4) Pilot lights.

5) Control relays.

6) Circuit breakers.

7) Indicating meters.

m. Verify that fuse and/or circuit breaker sizes and types conform to these specifications.

n. Verify that current and potential transformer ratios conform to these specifications.

o. Check bus connections for high resistance by low resistance ohmmeter and calibrated torque wrench applied to bolted joints.

1) Ohmic value to be zero.

2) Bolt torque level in accordance with NETA ATS, Table 10.1, unless otherwise specified by manufacturer.

p. Check operation and sequencing of electrical and mechanical interlock systems by:

1) Closure attempt for locked open devices.

2) Opening attempt for locked open devices.

3) Key exchange to operate devices in off-normal positions.

q. Verify performance of each control device and feature furnished as part of the motor control center.

r. Control wiring:

1) Compare wiring to local and remote control, and protective devices with elementary diagrams.

2) Check for proper conductor lacing and bundling.

3) Check for proper conductor identification.

4) Check for proper conductor lugs and connections.

s. Exercise all active components.

t. Inspect contactors for:

1) Correct mechanical operations.

2) Correct contact gap, wipe, alignment, and pressure.

3) Correct torque of all connections.

u. Compare overload heater rating with full-load current for proper size.

v. Compare fuse, motor protector, and circuit breaker with motor characteristics for proper

w. Perform phasing check on double-ended motor control centers to ensure proper bus phasing from each source.

x. Cable connections torque level in accordance with NETA ATS, Table 10.1, unless otherwise specified by the manufacturer.

y. Cable bends not in conformance with manufacturer's minimum allowable bending radius where applicable.

z. Color coding conformance with specifications.

aa. Proper circuit identification.

bb. Proper lug type for conductor material.

cc. Proper lug installation.

dd. Proper shield grounding on shielded instrumentation cable.

ee. Proper terminations.

ff. Proper circuit identification.

gg. Proper termination of neutrals and grounds for correct operation of protective devices.

2. Electrical tests:
    a. Insulation resistance tests:
        1) Utilize 1,000-volt dc megohmmeter for 600-volt insulated conductors and 500-volt dc megohmmeter for 300-volt insulated conductors.
        2) Test each conductor with respect to ground and to adjacent conductors per IEEE I 1 8 procedures for I minute.
        3) Evaluate ohmic values by comparison with conductors of same length and type.
        4) Investigate any values less than 50 megohms.
        5) Measure insulation resistance of each control circuit with respect to ground.
        6) Applied megohmmeter dc voltage in accordance with NETA ATS, Table 10.2.
        7) Bus section phase-to-phase and phase-to-ground for I minute on each phase.
        8) Contactor phase-to-ground and across open contacts for I minute on each phase.
        9) Starter section phase-to-phase and phase-to-ground on each phase with starter with starter contacts closed and protective devices open.
        10) Test values to comply with NETA ATS, Table 10.2.
    b. Overpotential tests:
        1) Maximum applied voltage in accordance with NETA ATS, Table 7.1.2.
        2) Phase-to-phase and phase-to-ground for I minute for each phase of each bus section.
        3) Test results evaluated on pass/fail basis.
    c. Current injection through overload unit at 300 percent of motor full-load current and monitor trip time:
        1) Trip time in accordance with manufacturer's published data.
        2) Investigate values in excess of 120 seconds.
    d. Control wiring tests:
        1) Apply secondary voltage to all control power and potential circuits.
        2) Check voltage levels at each point on terminal boards and each device terminal.
        3) Insulation resistance test at 1,000 volts dc on all control wiring except that connected to solid state components.
        4) Insulation resistance to be I megohm minimum.

3. Test values:

   a. Insulation resistance tests shall be performed at 1,000 volts D.C. for one-half (1/2) minute.

   b. Bolt torque levels shall be in accordance with manufacturer's specifications unless otherwise specified by manufacturer.

   c. Control wiring insulation test voltage shall be 500 V D.C. Manufacturer shall be consulted for test voltage where solid state control devices are utilized.

   d. Overload tests shall be made at three hundred percent (300%) of motor full load current. Trip times shall be in accordance with manufacturers tolerances. Values in excess of one hundred twenty (120) seconds shall be investigated.

   e. Insulation tests shall be made prior to termination.

D. Transformers:

1. General: Inspection and testing limited to motors rated 1/2HP and larger.

2. Visual and mechanical inspection for:

   a. Physical and insulator damage.

   b. Equipment nameplate information compliance with latest single line diagram and report discrepancies.

   c. Perform specific inspections and mechanical tests as recommended by manufacturer.

   d. Proper winding connections.

   e. Bolt torque level in accordance with NETA ATS, Table 1O. 1, unless otherwise specified by manufacturer.

   f. Defective wiring.

   g. Proper operation of fans, indicators, and auxiliary devices.

   h. Removal of shipping brackets, fixtures, or bracing.

   i. Free and properly installed resilient mounts.

   j. Cleanliness and improper blockage of ventilation passages.

   k. Correct tap-changer ratio setting for rated output voltage under normal operating conditions.

   l. Proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.

   m. Dissolved Gas Analysis (DGA Di-electric test, and moisture content test of oil.

3. Electrical tests:

   a. A dielectric absorption test shall be made on motor and starter circuit. Polarization index shall be determined for motor winding.

   b. A dielectric absorption test shall be made on motor winding. The thirty-sixty (30/60) second ratio shall be determined.

   c. Insulation resistance tests:

1) Applied megohmmeter dc voltage in accordance with NETA ATS, Table 7.2.3 for each:

    a) Winding-to-winding.

    b) Winding-to-ground.

2) 10-minute test duration with resistances tabulated at 30 seconds, I minute, and IO minutes.

3) Results temperature corrected in accordance with NETA ATS, Table 7.2.4.

4) Temperature corrected insulation resistance values equal to, or greater than, ohmic values established by manufacturer.

5) Insulation resistance test results to compare within I percent of adjacent windings.

d. Perform tests and adjustments for any fans, controls, and alarm functions as suggested by manufacturer.

e. Measure secondary voltages and adjust taps as directed by Engineer.

f. Turn to turn electrical testing for transformer integrity.

g. Measure no load and full load running current and voltage and compare to nameplate.

h. Observe proper operation and sequence of any reduced voltage starters.

i. Perform vibration base line test on motors greater than 50 HP. Amplitude to be plotted vs. frequency.

j. Perform vibration amplitude test on motors greater than 50 HP.

k. Check all protective devices in accordance with other sections of these specifications.

l. Perform over potential test on winding to ground.

m. The measurement shall be made with a 1,000 volt megohmmeter; however, the precautions noted in the tests for conductor test shall also be applied to the motors.

n. Insulation with resistance less than 10 megohms is not acceptable.

o. Measurements shall be recorded in a format similar to Form 16 05 08 - B, contained in this section.

p. After start-up of each motor, the current on each phase shall be measured.

    1) At no load.

    2) At defined load.

    3) In-rush current.

    4) Use Form 16 05 08 - B.

4. Test Values:

a. Dielectric absorption tests shall be made in accordance with test voltage listed as specified by manufacturer. Polarization tests shall before a ten (IO) minute duration. Sixty/thirty (60/30) second ratio tests shall be for a one (1) minute duration. Polarization index readings less than threes hall be investigated. Sixty/thirty(60/30)second ratio readings less than 1.4 shall be investigated.

b. Motor measured full load current shall not exceed nameplate value.

c. Over potential test shall be made an eighty percent (80%) of twice rated voltage plus one thousand (1,000) volts.

d. Vibration amplitudes shall not exceed values furnished by manufacturer.

E. Lighting:

1. Verify that the switching, including remote control is as shown.
2. Verify that the circuitry is in accordance with the panel schedules.
3. Verify that load is balanced as closely as possible.
4. Verify that the lighting fixtures are located to minimize obstruction of illumination by liquid-filled mechanical equipment or building structural elements.
5. Verify that photocell operates properly.
6. Replace all lamps that do not operate properly.

F. Switches:

1. Visual and mechanical inspection for:
   a. Proper blade pressure and alignment.
   b. Proper operation of switch operating handle.
   c. Adequate mechanical support for each fuse.
   d. Proper contact-to-contact tightness between fuse clip and fuse.
   e. Cable connection bolt torque level in accordance with NETA ATS, Table 10.1.
   f. Proper phase barrier material and installation.
   g. Proper fuse sizes and types as shown on single line diagram.
   h. Perform mechanical operational test and verify electrical and mechanical interlocking system operation and sequencing.
2. Electrical tests:
   a. Insulation resistance tests:
      1) Applied megohmmeter dc voltage in accordance with NETA ATS, Table 10.2.
      2) Phase-to-phase and phase-to-ground for I minute on each pole.
      3) Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
   b. Contact resistance tests:
      1) Contact resistance in microhms across each switch blade and fuse holder.

2) Investigate deviation of 50 percent or more from adjacent poles or similar switches.

G. Low Voltage Cables - 600 Volts and Below:

1. Visual and mechanical inspection for:

a. Physical damage and proper connection in accordance with single line diagram.

b. Cable connections torque level in accordance with NETA ATS, Table 10.1, unless otherwise specified by the manufacturer.

c. Cable bends not in conformance with manufacturer's minimum allowable bending radius where applicable.

d. Color coding conformance with specifications.

e. Proper circuit identification.

f. Proper lug type for conductor material.

g. Proper lug installation.

h. Proper shield grounding on shielded instrumentation cable.

i. Proper terminations.

j. Proper circuit identification.

k. Proper termination of neutrals and grounds for correct operation of protective devices.

2. Electrical tests:

a. Insulation resistance tests:

1) Utilize 1,000-volt dc megohmmeter for 600-volt insulated conductors and 500-volt dc megohmmeter for 300-volt insulated conductors.

2) Test each conductor with respect to ground and to adjacent conductors per IEEE I 1 8 procedures for I minute.

3) Evaluate ohmic values by comparison with conductors of same length and type.

4) Investigate any values less than 50 megohms.

b. Perform continuity test to insure proper cable connection.

c. Measurements shall be made prior to connection of wires to any equipment. Ends of wires are to be taped with Scotch 33+ and be physically remote from all grounded surfaces by a minimum of 2".

d. Insulation resistance measurements shall be recorded using Form 16960 - A contained in this section.

e. Insulation with resistance of less than 10 megohms is typically not acceptable.

f. Insulation resistance test shall be performed at 1,000 volts dc for one-half (1/2) minute. Insulation resistance readings shall be recorded after the one-half minute time interval has elapsed.

g. If in the opinion of the Engineer the test results are unacceptable, the

Contractor will correct the installation, material or labor at no additional cost to, and to the satisfaction of, the Engineer.

3. Test values:

a. Insulation resistance tests shall be performed at 1,000 volts D.C. for one-half (1/2) minute.

b. Insulation tests shall be made prior to termination.

H. Dry type Transformers:

1. Visual and mechanical inspection for:

a. Physical and insulator damage.

b. Equipment nameplate information compliance with latest single line diagram and report discrepancies.

c. Perform specific inspections and mechanical tests as recommended by manufacturer.

d. Proper winding connections.

e. Bolt torque level in accordance with NETA ATS, Table IO. 1, unless otherwise specified by manufacturer.

f. Defective wiring.

g. Proper operation of fans, indicators, and auxiliary devices.

h. Removal of shipping brackets, fixtures, or bracing.

i. Free and properly installed resilient mounts.

j. Cleanliness and improper blockage of ventilation passages.

k. Correct tap-changer ratio setting for rated output voltage under normal operating conditions.

l. Proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.

2. Electrical tests:

a. Insulation resistance tests:

1) Applied megohmmeter dc voltage in accordance with NETA ATS, Table 7.2.3 for each:

a) Winding-to-winding.

b) Winding-to-ground.

2) 10-minute test duration with resistances tabulated at 30 seconds, I minute, and IO minutes.

3) Results temperature corrected in accordance with NETA ATS, Table 7.2.4.

4) Temperature corrected insulation resistance values equal to, or greater than, ohmic values established by manufacturer.

5) Insulation resistance test results to compare within I percent of adjacent

windings.

b. Perform tests and adjustments for any fans, controls, and alarm functions as suggested by manufacturer.

c. Measure secondary voltages and adjust taps as directed by Engineer.

I. Lighting:

1. Verify that the switching, including remote control is as shown.
2. Verify that the circuitry is in accordance with the panel schedules.
3. Verify that load is balanced as closely as possible.
4. Verify that the lighting fixtures are located to minimize obstruction of illumination by liquid-filled mechanical equipment or building structural elements.
5. Verify that photocell operates properly.
6. Replace all lamps that do not operate properly.

J. Safety Switches, 600 volts maximum.

1. Visual and mechanical inspection for:

a. Proper blade pressure and alignment.

b. Proper operation of switch operating handle.

c. Adequate mechanical support for each fuse.

d. Proper contact-to-contact tightness between fuse clip and fuse.

e. Cable connection bolt torque level in accordance with NETA ATS, Table 10.1.

f. Proper phase barrier material and installation.

g. Proper fuse sizes and types as shown on single line diagram.

h. Perform mechanical operational test and verify electrical and mechanical interlocking system operation and sequencing.

2. Electrical tests:

a. Insulation resistance tests:

1) Applied megohmmeter dc voltage in accordance with NETA ATS, Table 10.2.

2) Phase-to-phase and phase-to-ground for I minute on each pole.

3) Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.

b. Contact resistance tests:

1) Contact resistance in microhms across each switch blade and fuse holder.

2) Investigate deviation of 50 percent or more from adjacent poles or similar switches.

K. Control Stations:

1. Visual and mechanical inspection for:
    a. Physical damage.
    b. Proper installation.
    c. Proper type and gasketing.
    d. Proper operation of pushbutton(s) and/or selector switch(es).
    e. Proper identification on nameplate.
    f. Proper control wiring:
        1) Compare to elementary diagram.
        2) Check for proper termination.
        3) Check for proper conductor identification.
2. Electrical tests:
    a. Control wiring tests:
        1) Apply proper voltage to all circuits.
        2) Check voltage levels at each termination.
        3) Insulation resistance test at 1,000 volts dc on all control wiring except that which is connected to solid state components. Insulation resistance to be one (1) megohm minimum.
    b. Operational test by initiating control devices to affect proper operation.

L. Local Control Panel(s) – LCP

1. Visual and mechanical inspection for:
    a. Physical damage.
    b. Proper type and installation of cabinet.
    c. Proper door closure and gasketing.
    d. Proper operation of pushbutton(s) and/or selector switch(es).
    e. Compliance with elementary diagrams and manufacturer's drawings.
    f. Proper identification on nameplates.
    g. Proper labeling of all devices both inside and outside.
    h. Proper control wiring:
        1) Compare to elementary diagram.
        2) Check for proper termination.
        3) Check for proper conductor identification.
    i. Proper overload protection for motor(s) when its starter is included in the panel.
    j. Proper breaker size and type.
    k. Proper CT when required.
    l. Proper terminal blocks.

2. Electrical tests:
   a. Control wiring tests:
      1) Apply proper voltage to all circuits.
      2) Check voltage levels at each termination.
      3) Insulation resistance test at 1,000 volts dc on all control wiring except that connected to solid state components. Insulation resistance to be one (1) megohm minimum.
   b. Operational test by initiating control devices to affect proper operation of each control signal and discrete signal loop.

M. Operating and Control System
1. Visual and mechanical inspection for:
   a. Physical damage.
   b. Proper type and installation of cabinet.
   c. Proper door closure and gasketing.
   d. Proper operation of pushbutton(s) and/or selector switch(es).
   e. Compliance with P&IDs and manufacturer's drawings.
   f. Proper identification on nameplates.
   g. Proper labeling of all devices both inside and outside.
   h. Proper control wiring:
      1) Compare to elementary diagram.
      2) Check for proper termination.
      3) Check for proper conductor identification.
   i. Proper terminal blocks.
   j. Equipment in compliance with these specifications.
   k. Operating equipment in compliance with these specifications.
   l. Operating screens in compliance with approved manufacturer's drawings.
   m. Annunciator screens in compliance with approved manufacturer's drawings.
   n. Alarm logs in compliance with approved manufacturers drawings.
2. Electrical tests:
   a. Control wiring tests:
      1) Apply proper voltage to all circuits.
      2) Check voltage levels at each termination.
      3) Insulation resistance test at 1,000 volts dc on all control wiring except that which is connected to solid state components. Insulation resistance to be one (1) megohm minimum.
   b. Operational test by initiating control devices to affect proper operation.

3.5 ADJUSTING

A. Subsystem Testing:

1. Shall occur after the proper operation of alarm and status contacts has been demonstrated and observed by the Engineer.

2. Shall occur after the process and control devices have been adjusted as accurately as possible.

3. It is intended that the Contractor shall adjust limit switches and level switches to their operating points prior to testing and will set pressure switches, flow switches, and timing relays as dictated by operating results.

4. After initial settings have been completed:

   a. Each subsystem shall be operated in the manual mode and it shall be demonstrated that operation is in compliance with the Contract documents.

   b. After the manual mode of operation has been proven, automatic operation shall be demonstrated to verify such items as proper start and stop sequence of pumps, proper operation of valves, proper speed control, etc.

5. Subsystems, in the context discussed here, shall mean individual and groups of pumps, conveyor systems, chemical feeders, air conditioning units, ventilation fans, air compressors, blowers, etc.

3.6 DEMONSTRATION

A. Commissioning:

1. Commissioning during the 7-day test as specified in Section “Facility Testing and Plant Start-up”, shall not be attempted until all subsystems have been found to operate satisfactorily.

2. Commissioning shall only be attempted as a function of normal plant operation in which plant process flows and levels are routine and equipment operates automatically in response to flow and level parameters or computer command, as applicable.

3. Simulation of process parameters shall be considered only upon receipt of a written request by the Contractor.

B. Motor current tabulation report shall reflect the values occurring during commissioning.

C. The indications of all switchgear ammeters and kilowatt meters, shall be recorded every half-hour during commissioning.

END OF SECTION

SECTION 16109
ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 SCOPE

A. Furnish all labor, materials, equipment, appliances, and perform all operations in connection with, and complete in strict accordance with, this section of specifications and the applicable drawings and subject to the terms and conditions of the contract for the following work:

1. Nameplates.
2. Labels.
3. Wire and cable markers.
4. Conduit markers.

1.2 APPLICABLE SECTIONS:

A. Section “Electrical General Requirements”.

1.3 SUBMITTALS:

A. Submit product literature including manufacturer name, model number, material, size, and specifications. Material shall not be installed until the Engineer has reviewed the submittal data.

PART 2 - PRODUCTS

2.1 NAMEPLATES:

A. Nameplates: Engraved three-layer laminated plastic, black letters on white background.

B. Locations:

1. Each electrical distribution and control equipment enclosure.
2. Communication cabinets.
3. Each junction box.

C. Letter Size:

1. 1/8" letters for identifying individual equipment and loads.
2. 1/4" letters for identifying grouped equipment and loads.

D. Identify control device stations, motor control equipment, process equipment and instrumentation equipment. All such devices shall be labeled with equipment served, identifying name, and circuit number with panel.

2.2 WIRE MARKERS:

A. Manufacturers:

   1. 3M
   2. Thomas & Betts
   3. Panduit

B. Description: Heat shrink tubing, imprinted, type wire markers.

C. Locations: Each conductor at panel-board gutters, pull boxes, outlet and junction boxes, and each load connection, PLC panels, instrument panels, instruments, MCC's, etc.

D. Legend:

   1. Power and Lighting Circuits: Branch circuit or feeder number shall be indicated on project Record Drawings.

E. Control Circuits: Control wire number shall be indicated on schematic and interconnection diagrams.

F. Data Wiring: Address number shall be indicated on each end of conductor on the face of the outlet cover, and on the space of the patch panel.

G. All conductor numbers and terminal block numbers shall be reflected on the CONTRACTOR submitted Record Drawings.

2.3 CONDUIT MARKERS:

A. Manufacturers:

   1. Tech Products
   2. Thomas & Betts
   3. Panduit

B. Description: 3/16" poly tag in poly tag holder. Tie wrapped to conduit.

C. Location: Furnish markers for each conduit longer than 6 feet.

D. Spacing: Label at each junction and terminal end.

E. Legend: Number as indicated in contractor prepared Record Drawings.

2.4 UNDERGROUND WARNING TAPE:

A. Description: 4" wide detectable plastic tape, colored red with suitable warning legend describing buried electrical lines.

B. Location: Along length of each underground conduit, 12" above conduit.

2.5 LABELS:

A. Self adhesive, plastic coated, machine printed.

B. Manufacturer: Brother or equal.

C. Locations:
   1. Convenience outlet circuit adhered to outlet faceplate showing panel and circuit number.
   2. Data address number to outlet faceplate and patch panel face plate.
   3. Light switches, indicating lighting switched panel and circuit number.
   4. Process wiring indicating connection point terminal block and cabinet.

PART 3 - EXECUTION

3.1 PREPARATION:

A. De-grease and clean surfaces to receive nameplates and labels.

3.2 INSTALLATION:

A. Install nameplate and label parallel to equipment lines.

B. Secure nameplate to equipment front using screws.

C. Secure nameplate to inside surface of door on panel-board that is recessed in finished locations.

D. Identify each conduit at each end.

E. Identify underground conduits using one underground warning tape per trench at 12" above conduit.

END OF SECTION

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SECTION 16116
PANELS AND CONSOLES

PART 1 - GENERAL

1.1 SUMMARY

A. General: This section sets forth the general specifications and requirements for all the control panels and enclosures being provided under this contract.

1. Including but not limited to all:

   a. All custom built and designed control panels.

2. The CONTRACTOR shall furnish, supply and install all custom panels for this project in accordance Contract documents.

3. This section also covers requirements for local control panels being supplied by the Equipment Manufacturers as part of the packaged equipment.

   a. The CONTRACTOR shall design all interfaces between these control panels and the SCADA/PLC System.

4. This specification covers the requirements for the fabrication of instrument panel boards or enclosures, mounting, finishing, piping and wiring of instrument equipment.

B. Related Sections:

1. The Contract Documents are a single integrated document, and as such all Divisions and Section apply. It is the responsibility of the CONTRACTOR and its Sub-Contracts to review all sections to insure a complete and coordinated project.

1.2 PANEL FABRICATION

A. The following paragraphs describe general fabrication requirements for the instrument panels, enclosures, and subpanels:

1. All internal instrument and component device wiring shall be as normally furnished by the manufacturer. With the exception of electronic circuits, all interconnecting wiring and wiring to terminals for external connection shall be stranded copper, insulated for not less than 600 volts, with a moisture-resistant and flame-retardant covering rated for not less than 90 C.

2. Power distribution wiring on the line side of panel fuses shall be minimum 12 AWG. Secondary power distribution wiring and wiring for control circuits shall be minimum 14 AWG. Annunciator and indicating light circuits shall be minimum 16 AWG. Electronic analog circuits shall be 16 AWG twisted and shielded pairs rated not less than 300 volts. Analog circuits shall be separated from ac power circuits. Wiring for ac power distribution, dc power distribution, and control circuits shall have different colors and shall agree with the color coding legend on the system supplier's panel wiring diagrams.

3. The power entrance to each panel shall be provided with a surge protection device. Surge protectors shall be nominal 120 volts ac with a nominal clamping voltage of 200 volts. Surge protectors shall be a non-faulting and non-interrupting design with a response time of not more than 5 nanoseconds. Surge protectors shall be Transtector "ACP-I00BW", Power Integrity Corporation "ZTAS", or equal.

4. Terminal blocks for external connections shall be suitable for No. 12 AWG wire, and shall be rated 30 amperes at not less than 300 volts. Terminal blocks shall be fabricated complete with marking strip, covers, and pressure connectors. Terminals shall be labeled to agree with identification shown on the Supplier's submittal drawings. A terminal shall be provided for each conductor of external circuits plus one ground for each shielded cable. All wiring shall be grouped or cabled and firmly supported to the panel. Not less than 8 inches of clearance shall be provided between the terminal strips and the base of vertical panels for conduit and wiring space. Not less than 25 percent spare terminals shall be provided. Each control loop or system shall be individually fused, and all fuses or circuit breakers shall be clearly labeled and located for easy maintenance.

5. The panel fabricator shall provide such additional circuits as may be indicated on the electrical schematic drawings.

6. Nameplates shall be provided on the face of the panel or on the individual device as required. Panel nameplates shall have approximate dimensions and legends as indicated on the drawings and shall be made of laminated phenolic material having engraved letters approximately 3/16 inch high extending through the black face into the white layer. Nameplates shall be secured firmly to the panel.

7. All panels shall be thoroughly cleaned, sanded, and given not less than one coat of rust-inhibiting primer both inside and out. The panel interior shall be given not less than one coat of white enamel or lacquer. All pits and blemishes in the exterior surface shall be filled. Exterior surfaces shall be smoothed and given not less than two coats of enamel, polyurethane, or lacquer finish. Color samples shall be submitted to the Engineer for color selection. One quart of finish color paint shall be furnished with the panels to cover future scratches.

B. FACTORY TEST

1. Panels shall be factory-tested electrically and pneumatically by the panel fabricator in the presence of the ENGINEER before shipment.

1.3 SUBMITTALS

A. Control Panel Engineering Submittals: Submit a two phase control panel engineering submittal for each and every control panel and enclosure being provided for this project.

1. Phase I shall be the Control Panel Hardware submittal which shall include but not be limited to:

a. Enclosure construction details and NEMA type.

b. Finish, including color chart for ENGINEER selection of color.

c. Layout.

d. Power circuits.

e. Signal and safety grounding circuits.

f. Fuses.

g. Circuit breakers.

h. Signal circuits.

i. Internally mounted instrumentation.

j. PLCs.

k. SCADA system components.

l. Face plate mounted instrumentation components.

m. Internal panel arrangements.

n. External panel arrangements.

o. Construction drawings drawn to scale which define and quantity.

    1) The type and gage of fabrication steel to be used for panel fabrication.

    2) The ASTM grade to be used for structural shapes and straps.

    3) Panel door locks and hinge mechanisms.

    4) Type bolts and bolt locations for section joining and anchoring.

    5) Details on the utilization of “UNISTRUT” and proposed locations.

    6) Stiffener materials and locations.

    7) Electrical terminal box and outlet locations.

    8) Electrical access locations.

    9) Print pocket locations.

    10) Writing board locations.

    11) Lifting lug material and locations.

p. Physical arrangement drawing drawn to scale which define and quantity the physical groupings comprising:

    1) Control panel sections.

    2) Auxiliary panels.

    3) Subpanels.

    4) Racks.

    5) Cutout locations with nameplate identifications shall be provided.

q. A bill of material which enumerates all devices associated with the control panel.

2. Phase II shall be the Control Panel Wiring Diagram submittal which shall include but not be limited to:

a. Schematic/Elementary diagrams shall depict all control devices and circuits and their functions.

b. Wiring/Connection diagrams shall locate and identify:

1) Electrical devices.

2) Terminals.

3) Interconnecting wiring.

4) These diagrams shall show interconnecting wiring by lines, designate terminal assignments, and show the physical location of all electrical and control devices.

c. Interconnection diagrams shall locate and identify all external connections between the control panel/control panel devices and associated equipment.

1) These diagrams shall show interconnecting wiring by lines, designate terminal assignments, and show the physical location of all panel ingress and egress points.

d. Control sequence diagrams shall be submitted to portray the contact positions or connections required to be made for each successive step of the control action.

3. All panel drawings shall be 22” x 34” reduced to and fully legible at 11” x 17”, and submitted at 11” x 17” format size, with all data sheets and manufacturer specification sheets being 8.5” x 11”.

4. The submittal shall be in conformance with NEMA Standard ICS-1-1.01, and each phase shall be submitted as a singular complete bound volume or multi-volume package and shall have the following contents.

a. A complete index shall appear in front of each bound volume.

1) All drawings and data sheets associated with a panel shall be grouped.

2) All panel tagging and nameplate nomenclature shall be consistent with the requirements of the Contract Documents.

b. Completed ISA-S20 data sheets for all instrumentation devices associated with each control panel supplemented with manufacturer specification sheets which verify the products conformance to the requirements of the Contract Documents.

c. A listing of spare parts in conformance with each equipment specification section.

1.4 QUALITY ASSURANCE

A. Environmental Suitability:

1. All indoor and outdoor control panels and instrument enclosures shall be suitable for operation in the ambient conditions associated with the locations designed in the Contract Documents.

2. Heating, cooling, and dehumidifying devices shall be provided in order to maintain all instrumentation devices to within a range equal to 20% above the minimum and 20% below the maximum of the rated environmental operating ranges.
3. Provide all power wiring for these devices.
4. Enclosures suitable for the environment shall be furnished.
5. All instrumentation in hazardous areas shall be suitable for use in the particular hazardous or classified location in which it is to be installed.

B. All control panels and assemblies shall be labeled and listed by a nationally recognized testing laboratory.
1. Underwriters Laboratory, Inc.
2. Or equal.

1.5 DELIVERY, STORAGE AND HANDLING

A. All panels are to be crated for shipment using a heavy framework and skids.
1. The panel sections shall further be cushioned satisfactorily to protect the finish of the instruments and panel during shipment.
2. All equipment which is shipped with the panel shall further have suitable shipping stops and cushioning material installed in a manner to protect instrument parts which could be damaged due to mechanical shock during shipment.

PART 2 - PRODUCTS

2.1 CONTROL PANELS

A. The following paragraphs describe specific requirements for the control panels:

B. CONSTRUCTION - NEMA 12 by Hoffman or equal in control room locations. NEMA 4X by Hoffman or equal in process or humid areas or outside.
1. NEMA 12
a. Seams continuously welded and ground smooth.
b. Door and body stiffeners as needed to make a rigid enclosure.
c. Heavy gauge continuous hinge.
d. Oil-resistant gasket attached to door with oil-resistant adhesive. Gasket to seal against roll lip on the enclosure opening.
e. Internal mounting panel held in place by collar studs welded to enclosure.
f. Lockable door latching and handle mechanism to allow easy access to interior of enclosure and keyboard.
g. Panel cut-outs for instruments, devices, and windows shall be cut, punched, or drilled and smoothly finished with rounded edges.
1) Reinforce around cut-outs with steel angles or flat bars.
2. Large panel cutouts such as for HMIs.

3. Pilot device groupings where the removed metal exceeds 50% of the available metal in an area bound by a 3” envelope around said pilot devices.

   a. Finish.

      1) Interior, smooth, polyester power coating.

      2) Exterior polyester powder coating gray in color.

         a) Panels that re in the same room as, motor control centers, switchboards, etc shall be of the same color as the motor control center or switchboards so that the control panel blends into the line up.

   b. Manufacturer’s standard gauge steel.

   c. Each door to have a three-point latching mechanism and padlocking handle with rollers on the ends of the latch rods.

   d. With heavy duty lifting eyes.

   e. With flange mounted disconnect.

   f. Mounting panel

      1) 10 gauge steel

      2) With stiffeners

4. Water tight corrosion resistant stainless steel

   a. NEMA 4X in design, dust tight, water tight, and corrosion-resistant.

   b. 14 gauge, Type 304 Stainless Steel.

   c. Captive stainless steel cover screws threaded into sealed wells.

   d. Oil resistant neoprene sealing gasket and adhesive to seal cover to enclosure.

   e. Finish

      1) Cover surface and sides, unpainted, brushed finish.

   f. Door fronts ground smooth.

   g. Specifically designed for use with flange mounted disconnect switches.

C. SIZE AND ARRANGEMENT - Panel dimensions and general instrument arrangement shall be as indicated on the drawings.

D. Interconnecting wiring and wiring to terminals for external connection shall be MTW or SIS 16 AWG, stranded copper wire, insulated for not less than 600 volts, with a moisture-resistant and flame-retardant covering rated for not less than 90 degrees Celsius except for electronic circuits and special instrument interconnect wiring which shall be in accordance with manufacturer requirements. Provide a switched fluorescent light at every four feet of panel length.

E. PANEL WIRING:

1. Power distribution wiring on line side of panel fuses minimum 12 AWG.
2. Secondary power distribution wiring and wiring for control circuits: Minimum number 14 AWG.
3. Annunciator and indicating light circuits: Minimum 14 AWG.
4. Electronic analog circuits within instrument and control panels: Minimum 16 AWG twisted and shielded pairs or triads rated not less than 16 volts.
5. Provide a 15 amp, 120 volt GFCI service outlet within each panel.
6. Wire Insulation Colors:
    a. Conductors supplying 120-volts AC power on the line side of a disconnecting switch shall have a black insulation for the ungrounded conductor.
    b. Grounded circuit conductors shall have white insulation.
    c. Insulation for ungrounded 120-volt AC control circuit conductors shall be red.
    d. All wires energized by a voltage source external to the control panels shall have yellow insulation.
    e. Insulation for all DC conductors shall be blue.
7. Wire Marking:
    a. Each signal, control, alarm, and indicating circuit conductor connected to a given electrical point shall be designated by a single unique number which shall be shown on all shop drawings.
    b. These numbers shall be marked on all conductors at every terminal.
8. For case grounding, panels shall be furnished with a ¼-inch by 1-inch copper ground bus complete with solderless connectors for all equipment ground conductors.
    a. Refer to Division 16 – Conduit Schedule for size and number of conductors.
9. Power Supply Wiring:
    a. Each and every loop and instrument requiring 120 VAC shall be protected by individual DIN rail mounted circuit breakers.
        1) The number of circuits depends on the circuit load as noted herein.
        2) The circuit load shall not exceed 10 amp.
        3) Different panel section or different process units must not use common branch circuits.
        4) Furnish and install DIN rail mounted circuit breakers for all individual instruments.

a) Circuit breakers shall be mounted on the back of the panel.

b) Identified by a service name tag.

b. Each potentiometer type instrument, electronic transducer, controller or analyzer shall have an individual DIN rail mounted circuit breaker located within the control panel.

1) Circuit breakers shall have plastic tags indicating instrument tag numbers.

2) Individual plug and cord set power supply connections require DIN rail mounted circuit breakers ahead of the receptacle.

10. Furnish circuit breakers for the panel lights, and for the panel receptacle.

11. Alarm Wiring:

a. Install and wire all alarms including light cabinets, audible signal units, test and acknowledge switches and remote logic units as specified.

b. Interconnecting wiring to panel mounted initiating devices shall also be wired.

c. Where plug and cord sets are provided for component interconnection, harness and support the cables in neat and orderly fashion. Where separate wire is required, install No. 16 AWG with MTW or TFFN insulation between all components.

12. Signal Wiring:

a. Signal Wire – Non Computer Use

1) Signal wire shall be twisted pair or triads in conduit or troughs. Cable shall be constructed of No. 16 AWG with MTW or TFFN insulation between all components.

2) Color code for instrument signal wiring shall be as follows:

a) Positive (+) – Black

b) Negative (-) – White.

3) Multiconductor cables where specified shall consist of No. 18 AWG copper signal wires twisted in pairs, pairs, with 90°C, 600 V insulation.

a) A copper drain wire shall be provided for the bundle with a wrap of aluminum polyester shield. The overall bundle jacket shall be PVC.

4) Use for connections between field terminal blocks and the PLC wiring arms for analog inputs and outputs.

b. Signal Wire – Computer Use

1) Signal wires shall be similar to those for non-computer use but each pair shall be triplexed with a copper drain wire and aluminum polyester tape shall be applied over the triplexed group.

2) All cable shields, including thermocouple extension leads shall be terminated at a single point within the control panel.

3) Continuity of the shield is to be maintained throughout the cable runs.

c. Multi-conductor cables, wireways and conduit shall be sized to allow for 20 percent signal wire.

13. Wiring Installation:

a. All wires shall be run in plastic wireways.

b. Exception:

1) Field wiring.

2) Wiring run between mating blocks in adjacent sections.

3) Wiring runs from components on a swing-out panel to components on a part of the fixed structure.

a) Wiring run from components on a swing-out or front panel to other components on a fixed panel shall be made up in tied bundles.

b) These bundles shall be tied with nylon wire ties, and shall be secured to panels at both sides of the "hinge loop" so that conductors are not strained at the terminals.

4) Wiring run to front panel-mounted components.

c. Signal and low voltage wiring shall be run separately from power and 120 VAC control wiring.

1) 120 VAC circuits shall be run through grey colored plastic wireways.

2) 24 VDC circuits shall be run through white colored plastic wireways.

d. Wiring to rear terminals on panel-mount instruments shall be run in plastic wireways secured to horizontal brackets run above or below the instruments in about the same plane as the rear of the instruments.

e. Provide an empty wireway for all field wiring connections.

1) 120 VAC circuits shall be run through grey colored plastic wireways.

2) 24 VDC circuits shall be run through white colored plastic wireways.

f. Conformance to the above wiring installation requirements shall be reflected by details shown on the shop drawings for the ENGINEER’s review.

14. Grounding

a. Furnish equipment ground bus with lugs for connection of all equipment grounding wires.

F. ANALOG CIRCUITS AND AC POWER CIRCUITS: Separated.

G. INTERNAL PANEL WIRING COLORS:

a. AC Power Distribution: Red

b. DC Power and Control: Blue

c. Instrument: Black and white twisted shielded pair.

d. Other and in agreement with manufacturer's wiring diagrams as stated on manufactured drawing legend.

H. SURGE PROTECTION DEVICE FOR POWER ENTRANCES: Nominal 120 volts AC with a nominal clamping voltage of 200 volts; nonfaulting and noninterrupting design with a response time of not more than 5 nano-seconds. Utilize a branch panel TVSS unit.

I. TERMINAL BLOCKS FOR EXTERNAL CONNECTIONS: Suitable for specified AWG wire, rated 30 amperes at not less than 600 volts (for incoming power circuits, and for field 1/0 terminals they shall be Phoenix contact or equal as shown on the drawings); with marking strip, covers, pressure connectors, and labeled terminals, each conductor of external circuits plus one ground terminal for each shielded cable. Provide minimum 25 percent spare terminals.

J. Group cables, and firmly support wiring to the panel. Provide minimum 8 inches clearance between terminal strips and the base of vertical panels for conduit and wiring space. Individually fuse each control loop or system, and clearly label and locate fuses or circuit breakers for maintenance.

K. Furnish and install equipment grounding conductor in accordance with NEC 250. Provide power ground lugs. Provide signal insulated and isolated ground lugs.

L. Nameplates on Internal and External Instruments and Devices: Materials approximate dimensions with legends as indicated on the Drawings made of laminated phenolic material having engraved letters approximately 3/16 inch high extending through the black face into the white layer; firmly secured to panels.

M. POWER SUPPLIES/FUSING

1. Design and arrange regulated 24 volt DC power supplies for instrument loops so that loss of I loop does not affect more than one instrument loop or system. Provide power supplies suitable for an input voltage variation of plus or minus 10 percent. Fuse or short circuit protects the supply output.

2. Selectively fuse the power distribution from multi-loop supplies so that a fault in one instrument loop will be isolated from the other loops being fed from the same supply. Label and locate fuses for easy access.

3. Output Voltage Regulation: As required by the instrument or control equipment being supplied.

4. Backup power supply units shall be provided to automatically supply the load upon failure of the primary supply. Design backup supply systems so that either the primary or backup supply can be removed, repaired, and returned to service without disrupting the instrument system operation.

5. Oversize the multi-loop supply systems for an additional 25 percent future load. Indicate failure of a multi-loop supply on the respective instrument panel or enclosure.

6. Furnish and install signal repeaters for instrument loops that exceed the load impedance of the power supplies. Indicating fuses: Neon bulb type for 120 VAC circuit and glass indicating fuse type for 24 VDC circuits.

N. SOURCE QUALITY CONTROL:

1. Functionally factory test instrument and control panel items electrically and pneumatically before shipment.

O. PANEL ACCESSORIES:

1. Manufacturers: Weidmuller SAKS; Entrelec; Phoenix Contact; Wago; or equal.

a. Terminal Blocks: Nickel plated copper only; DIN rail; universal foot with the following as required for the application.

1) Universal type

2) Feed through

3) Ground

4) Neutral disconnect

5) Intrinsically safe

6) Explosion-proof

7) Fuse

8) Knife disconnect

9) Ground fault indicator

10) Bolt connecting

b. Terminal Block Labeling: Each terminal and each conductor as previously specified with machine labels only.

1) Manufacturers: Phoenix Contact; Entrelec; or equal.

a) Signal Interface Modules:

1. Analog isolating converter

2. Ground loop isolations
3. Signal amplification
4. Signal level matching
5. 24 VDC power supply (120 VAC input)

2. Disconnect Switches:
   a. Switches shall consist of a thermal magnetic circuit breaker with integral door operator – lockable
      1) Minimum 22 KAIC
      2) Not required for panels fed with 120 VAC or less. A nameplate must be furnished on the cover of the control panel identifying all sources of supply and foreign voltages within the control panel.
   b. The main disconnect shall disconnect all power sources within the control panel.
   c. Sized in accordance with the NEC and total connected horsepower and associated locked rotor currents.
   d. A disconnect shall be provided for each motor controller/starter within the control panel. This disconnecting means shall disconnect power and control power to each motor controller. Each disconnect shall be equipped with a dead front operator through either the cabinet door or a dead front panel.

PART 3 - EXECUTION

END OF SECTION

SECTION 16119
CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish and install conductors and cables as required, and as shown on the Drawings. Materials employed shall be as indicated on the Drawings and specified herein.

1.2 SUBMITTALS

A. Submit product literature including manufacturer part number, model number, material, size, and specifications. Material shall not be installed until the Engineer has reviewed the submittal data.

B. Shop Drawings shall be submitted for review and acceptance showing routing, conduit size, and number and size of wires in each conduit before installation of conduit and any related work. Show proposed routing of conduits buried under floor slabs-on-grade, conduit and rebar embedded in floor slabs, columns, etc. Identify conduit by tag number of equipment served and by conduit schedule number.

1.3 QUALITY ASSURANCE

A. MANUFACTURERS: Firms regularly engaged in manufacture of conduits and raceway systems of type and sizes required, whose products have been in satisfactory use in similar service for not less than (3) years.

B. STANDARDS: Comply with applicable portions of the NEMA standards pertaining to raceways. Comply with applicable portions of UL safety standards pertaining to electrical raceway systems; and provide products and components which have been UL listed and labeled. Comply with NEC requirements as applicable to construction of raceway systems.

1.4 APPLICABLE SECTIONS

A. Section "Electrical General Requirements".

B. Section "Electrical Acceptance Tests".

PART 2 - PRODUCTS

2.1 COMPONENTS

A. 600 Voltage Conductors:

1. Copper with AWG sizes as shown or required:

    a. Minimum size shall be No. 12 except where specified otherwise.

    b. Conductors shall be stranded.

        1) Insulation:

            a) Conductor Size No. 2 And Smaller: 600V type THWN or XHHW (75° C). All conductors run in underground conduits shall be XHHW.

b)

c) Conductor Size No. 1 And Larger: 600V Type XHHW-2 (90° C).

2) Colors:

a) 120/240 V System

(1) Black: Line 1.

(2) Red: Line 2.

(3) Green: Ground.

(4) White: Neutral.

b) 208Y / 120 V System:

(1) Black: Phase A.

(2) Red: Phase B.

(3) Blue: Phase C.

(4) Green: Ground.

(5) White: Neutral.

c) 480Y / 277 Volt System:

(1) Brown: Phase A.

(2) Orange: Phase B.

(3) Yellow: Phase C.

(4) Neutral: Gray.

(5) Ground: Green.

d) Conductors size No. 10 and smaller shall be colored full length. Tagging or other methods for coding of conductors size No. 10 and smaller not allowed.

e) For feeder conductors larger than No. 10 at pull boxes, gutters, and panels, use taped band or color tag color-coded as specified above.

B. Instrumentation Cables:

1. Instrument cable shall be Type TC, and have the number of individually shielded twisted pairs indicated on the Drawings and shall be insulated for not less than 600 volts. Unless otherwise indicated, conductor size shall be No. 18 AWG minimum. Shielded, grounded instrumentation cable shall be used for all analog and low voltage digital signals.

2. The jacket shall be flame retardant with 90 degrees C temperature rating. The cable shield shall be a minimum of 2.3 mil aluminum or copper tape overlapped to provide 100 percent coverage and a tinned copper drain wire.

3. The conductors shall be bare soft annealed copper, Class B, 7 strand minimum concentric lay with 15 mils nominal thickness, nylon jacket, 4 mil nominal thickness, 90 degrees C temperature rating. One conductor within each pair shall be numerically identified.

4. Pairs shall be assembled with a nominal 2-inch lay and shall then be group shielded with a minimum of 1.3 mil aluminum or copper tape overlapped to provide 100 percent coverage. All group shields shall be completely isolated from each other.

C. Control Wires:

1. Copper with AWG sizes as shown or required:

   a. Minimum size shall be No. 14 except where specified otherwise.

   b. Conductors shall be stranded.

      1) Insulation:

         a) 600V type THWN or XHHW (75° C). All conductors run in underground conduits shall be XHHW.

2. Control wires may be run in same conduits as instrumentation cables.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:

1. Conductors and cables shall be continuous from source to equipment.

2. Do not use direct burial cable.

3. Instrumentation and control wires shall be run in conduits separate from power conduits.

B. 600 Voltage Conductors:

1. Install conductors in raceway except where specifically indicated otherwise. Run conductors of different voltage systems in separate conduits. All raceways shall include an equipment ground conductor.

2. Route circuits at own discretion, however, circuiting shall be as indicated or required. Group circuit homeruns to panels as shown on Drawings. No other groupings of circuits will be allowed.

3. Neutrals:

   a. On three-phase, 4-wire systems: Do not use common neutral for more than one three phase circuit.

   b. On single-phase, 3-wire systems: Do not use common neutral for more than one circuit per phase.

   c. Run separate neutrals for each circuit where specifically noted on Drawings.

   d. Where common neutral is run for two or three home run circuits, connect phase conductors to breakers in panel which are attached to separate phase legs so neutral conductors will carry only unbalanced current. Neutral shall be sized at 200% of full load.

4. Pulling Conductors:

a. Do not pull conductors into conduit until raceway system is complete and enclosures, cabinets, and boxes are free of foreign matter and moisture.

b. Install conductors in accordance with the manufacture's requirements.

c. Use only listed non-hardening wire pulling lubricants.

5. Provide positive supports for conductors in vertical raceways at following spacing minimum, unless shorter is recommended by manufacturer.

a. No. 18 to 1/0 100 feet.

b. No. 2/0 to 4/0 80 feet.

c. 250MCM to 350MCM 60 feet.

d. d. 350MCM to 500MCM 50 feet.

C. Feeder and branch circuits shall be isolated from each other, and from instrumentation and control circuits. Instrumentation cables shall be installed in separate raceways from other cables and wiring. This includes portions running through manholes. Instrumentation cable shall be continuous between instruments or between field devices and instrument enclosures. There shall be no intermediate splices or terminal boards, unless otherwise shown on the Drawings.

D. Maintain electrical continuity of the shield when splicing twisted shielded pair conductors. Drain wires shall be terminated inside enclosures at grounded terminal blocks. Only one end of each instrument loop cable drain wire shall be grounded. Ground drain wire of shielded conductors at one end only.

E. Terminate instrumentation and control wiring, including spare wires, at control panels and motor control centers on terminal boards mounted inside the equipment.

1. CONTRACTOR shall supply terminal boards as required.

2. Do not field wire directly to devices.

F. Low Voltage Cables In Office Spaces (70 Volts or Less):

1. In inaccessible, concealed spaces, run cables in raceway. In accessible, unfinished areas, cables may be run exposed without raceway.

2. Run exposed cables parallel to or at right angles to building structure lines. Do not run exposed cables on floors or in such a way that they obstruct access to, operation of, or servicing of equipment. Keep cables 6 inches minimum from hot water pipes.

a. Support cables every 3 feet with permanent clips, straps, staples, or tie wraps approved for application and which will not cause cables to be pinched or deformed.

b. Securely attach clips and straps with nails or screws. Do not use wire or tape to support cables.

3. Bundle only cables of same systems together.

END OF SECTION

SECTION 16125

OPERATION AND MAINTENANCE MANUALS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specifications sections, apply to work of this section.

B. Division-16 Electrical General Requirements sections apply to work of this section.

1.2 SUMMARY

A. Furnish four sets of bound operation and maintenance manuals. Manuals shall contain descriptive drawings and data which identify equipment installed at the project and detail the procedures and parts required to maintain and repair the equipment. Copies of approved submittals shall be included for all equipment.

1.3 OPERATION AND MAINTENANCE MANUAL FOR ELECTRICAL AND INSTRUMENTATION SYSTEMS

A. General:

1. The "Operating and Maintenance Manual" (Electrical and Instrumentation) is a bound compilation of drawings and data that the owner requires for each building or project. These manuals, complete with drawings and data, shall be furnished to the Owner.
2. The electrical CONTRACTOR has overall responsibility to obtain the necessary data and compile the data as set forth in this specification, including items or equipment purchased by the Owner and delivered to the CONTRACTOR for installation.
3. The number of binders (or "volumes") required will depend on the amount of information to be catalogued. Total "sets" see paragraph 1.02A.
4. Make all information legible and sufficiently marked to indicate the exact size, model, type, etc., of equipment furnished and installed.

B. Purpose: The Operating and Maintenance Manual is prepared to provide a ready reference to all important pieces of mechanical and electrical equipment installed on the project. It is also to provide the necessary operating and maintenance data for use by service personnel. It is also to provide information required for checking equipment performance or for planning of plant expansion or redesign.

PART 2 - PRODUCTS

2.1 PAGE SIZE:

A. All pages shall be standard 8-1/2 x 11 inches size or approximate multiples (preferably 11 x 17 inches) folded to 8-1/2 x 11 inch.

2.2 DRAWINGS:

A. All drawings larger than 8-1/2" x 11" shall be folded and inserted in individual 8-1/2" x 11" manila pockets, which shall have standard three-ring side punching for insertion in the binders. The equipment name, drawing description and number shall be written on the face of each manila pocket.

2.3 BINDERS:

A. Binders shall be Buckram (stiffened fabric), bar-lock type binders with block lettering for sheet size 8-1/2 x 11 inches with 2" to 3-1/2" expandable metal capacity as required for the project. The number of binders, however, shall be based on not filling them beyond 4".

B. Place the following information on the front cover and backbone:

1. "Operation and Maintenance Manual".
2. Project Name and Number (and volume number if more than one volume).
3. Equipment name and number.
4. ENGINEER's name.
5. General CONTRACTOR's name.
6. Electrical CONTRACTOR's name.

(Items 4 through 6 need not be printed on the backbone.)

2.4 CONTENTS AND INDEXING

A. Manuals shall contain descriptions of the electrical, control, and instrumentation systems in sufficient detail to adequately indicate the type of systems installed and the basic details of their operation.

B. All purchased equipment data shall be used to designate the sections. Within each section additional indexing of component parts may be required.

C. Operation and Maintenance Manuals shall contain to the fullest extent all possible information pertinent to the equipment. The arrangement and type of information to be filed shall be as follows:

1. Copy of purchase order change (if any).
2. Outline drawings, special construction details, “as-built” electrical wiring and control diagrams with wire and terminal number for panel and field wiring for all major and supplementary systems.
3. Manufacturer’s test or calculated performance data and certified test curves.
4. Installation, operating, and maintenance instructions, including a complete parts list and sectional drawing with parts identification numbers. Mark with model, size and plan number.
5. Manufacturer’s brochure marked to indicate exact equipment purchased. Brochures on component parts supplied by a manufacturer with his equipment, but not manufactured directly by him, shall also be included.

6. The serial numbers of each item of equipment installed are to be listed with the model numbers and plan symbols.
7. Include a Table of Contents. The contents shall be divided with tabbed index dividers into the following suggested parts:

   Part I Building and System Descriptions

   Part II Purchased Equipment Data

   Part III Test Reports and Charts

   Part IV Start-Up and Operation

   Part V Preventative Maintenance Recommendations

   Part VI Software/Programming Data/Program CD's
8. A copy of the approved submittals for each piece of equipment.
9. A copy of all testing reports.
10. Wiring diagrams, marked with model and size and plan symbol.
11. The index shall contain the name and address of the manufacturer and, if different, where replacement and repair parts may be obtained.
12. Copies of developed software, programmed setpoints, screens, etc. on C.D.

END OF SECTION

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SECTION 16131
CONDUIT

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish and install conduits and raceway systems as required, and as shown on the Drawings. Materials employed shall be as indicated on the Drawings and specified herein.

1.2 SUBMITTALS

A. Submit product literature including manufacturer part number, model number, material, size, and specifications. Material shall not be installed until the Engineer has reviewed the submittal data.

B. Shop Drawings shall be submitted for review and acceptance showing routing, conduit size, and number and size of wires in each conduit before installation of conduit and any related work. Show proposed routing of conduits buried under floor slabs-on-grade, conduit and rebar embedded in floor slabs, columns, etc. Identify conduit by tag number of equipment served and by conduit schedule number.

C. Proposed location and details of construction for openings in slabs and walls for conduit runs.

1.3 QUALITY ASSURANCE

A. MANUFACTURERS: Firms regularly engaged in manufacture of conduits and raceway systems of type and sizes required, whose products have been in satisfactory use in similar service for not less than (3) years.

B. STANDARDS: Comply with applicable portions of the NEMA standards pertaining to raceways. Comply with applicable portions of UL safety standards pertaining to electrical raceway systems; and provide products and components which have been UL listed and labeled. Comply with NEC requirements as applicable to construction of raceway systems.

1.4 PROJECT/SITE CONDITIONS

A. GENERAL:

1. Unless otherwise specified, equipment and materials shall be sized and derated for ambient site conditions, but in no case less than an ambient temperature of 40 degrees C at an elevation ranging from seal level to 1,601 feet without exceeding the manufacturer's stated tolerances.

B. AREA CLASSIFICATIONS

1. For the purpose of delineating the basic electrical construction materials and installation requirements for this project, areas of the project have been classified on the contract drawings as defined below. Electrical work within these areas shall conform to the requirements described below as well as the referenced code requirements.

   a. General Purpose (NEMA 1): Areas requiring general purpose (NEMA 1) construction are indoor areas typically architecturally finished and occupied by plant personnel.

b. Outdoor and Corrosive Process Areas (NEMA 4X): Areas requiring corrosion resistant (NEMA 4X) construction are all outdoor areas unless noted otherwise and all indoor corrosive process areas. Corrosive process areas typically contain pumping or piping systems and are subject to spills and washdown. Corrosive process areas shall also include those areas containing corrosive chemicals.

c. Hazardous Areas (NEMA 7): Unless otherwise indicated on the contract drawings, areas requiring hazardous location (NEMA 7) construction are classified as Class 1, Division 2 or Class1, Division 1 hazardous locations per Articles 500 and 501 of the National Electrical Code. See classification drawings.

d. Process Areas (NEMA 12): Areas requiring drip-proof (NEMA 12) construction are indoor process and support system areas and are not typically subject to spills, direct washdown, or corrosive chemicals under normal operating conditions.

C. CONSTRUCTION MATERIALS:

1. Construction materials required for each area classification are listed in table A below. Refer to the individual specification section for each component for material composition and installation practices.

	Area Classification				
Component	NEMA 1	NEMA 4X[1] Outdoor	NEMA 4X[1] Indoor Corrosive	NEMA 12[1]	NEMA 7 Classified Explosion Proof/Process Area
Conduit (exposed)	GRS	RA[7] PGRS	PVC8 PGRS	GRS PGRS	PGRS
Conduit (concealed)[4]	EMT[3]	GRS	PVC4	GRS	GRS
Flexible conduit[5]	LFS	LFS	LFN	LFN	Classified
Support systems	Galvanized Steel	Aluminum	Stainless steel	Aluminum	Stainless steel
Fastening hardware and hanger	Cadmium plated steel	Stainless steel	Stainless steel	Cadmium plated steel	Stainless steel
Control Stations[2],	Painte d	Non-Metallic	Non-Metallic	Painted Steel	Classified
Enclosures[2,6]	Painte d	Non-Metallic	Non-Metallic	Painted Steel	Classified
Receptacles[2] Surface Recessed	General General	WP 8	WP[8] N/A	WP 8	Classified N/A

Switches[2] Surface Recessed	General General	WP 8	WP[8] N/A	WP 8	Classified N/A

Notes:

1. Enclosures, device boxes, control stations and raceway systems shall be mounted with ¼-inch (minimum) space between the electrical system and supporting structure.
2. Conduit terminations to control stations, enclosures, and device boxes in NEMA 4X, 7 and 12 areas shall be made through threaded hubs.
3. Rigid conduit concealed in framed walls, block walls and ceiling spaces shall be electrical metallic tubing, type EMT.
4. Conduit ductbank or beneath slab on grade shall be rigid HDPE conduit, continuous from device to device without pullboxes or conduit splices beneath grade due to high water table..
5. Flexible conduit shall be utilized for final connections to equipment.
6. Control station and enclosure sealing ratings shall meet or exceed the rating designated by the area classification.
7. Exposed conduit systems in areas containing equipment handling Ferric Chloride shall be PGRS.
8. Use gasketed lever type switches and up-in use red dot steel receptacle covers.

Legend:

EMT Electrical Metallic Tubing
GRS Galvanized Rigid Steel
LFS Liquid Tight Flexible Steel
LFN Liquid Tight Flexible Non-Metallic
PGRS PVC Coated Galvanized Rigid Steel
PVC4 PVC Schedule 40
PVC8 PVC Schedule 80
RA Rigid Aluminum
WP Weatherproof – Use cast device boxes with threaded hubs
XP Explosion proof – Approved conduit systems per classification listing
N/A Non applicable

PART 2 - PRODUCTS

2.1 CONDUIT AND TUBING

A. GENERAL: Provide conduit and fittings of types, grades, sizes and weights (wall thicknesses) as indicated; with minimum trade size of 3/4".

B. ELECTRICAL METALLIC TUBING (EMT):

1. Per UL "Standard for Electrical Metallic Tubing" No. 797. Galvanized mild steel with interior coat of enamel.
2. Fitting shall be steel, compression type. Cast type or indenter type fittings are not acceptable.
3. Approved for interior locations of the Administration Building, and for concealed installation above ceilings and in walls for receptacle and lighting circuits.
4. Not approved for use in classified areas or process areas of the plant.

C. GALVANIZED RIGID METAL CONDUIT (GRC): FS WW-C-0581 and ANSI C80.1.

1. Per USAS C80.1, zinc-coated by hot-dip galvanizing or sherardizing with additional enamel or lacquer coating.
2. Couplings shall be threaded type of same material and finish as conduit. Connectors shall be Myers hubs or equal of same material and finish as conduit.
3. Approved Locations: Interior where exposed, where not exposed to moisture or corrosive atmosphere. Shall not be used in process areas of the plant.

   SCHEDULE 80 approved for above grade installation and for embedding in concrete slabs. Schedule 80 may be used within the process area of the plant, supported in frequent intervals, as per NEC, except elbows below concrete and risers through concrete shall be PVC Coated Ridged Conduit.

D. POLYETHYLENE PLASTIC PIPE (PVC), SCHEDULE 80, Based on Outside Diameter: ASTM D 2447

1. Un-plasticized polyvinyl - chloride heavy wall (PVC-80).
2. Fittings shall be threaded or solvent welded type of same material as conduit.
3. SCHEDULE 80 approved for above grade installation and for embedding in concrete slabs. Schedule 80 may be used within the process area of the plant, supported in frequent intervals, as per NEC, except elbows below concrete and risers through concrete shall be PVC Coated Ridged Conduit.
4. Threaded male plastic adapters shall be used where connected to metal conduits.

E. POLYETHYLENE PLASTIC PIPE (PVC), SCHEDULE 40, Based on Outside Diameter:

1. Un-plasticized polyvinyl - chloride standard (PVC-40).
2. Fittings shall be threaded or solvent welded type of same material as conduit.
3. Approved for underground direct burial, May be used where buried in earth under floor slabs. Minimum depth of bury under slab shall be 18 inches or of sufficient depth to allow for bending radius to rise out of the slab vertically. Shall have an exposed grounding electrode conductor in each trench.
4. Not approved for above grade installation nor for embedding in concrete slabs. Not approved for elbows or risers above 22.5 degree bend.

F. HIGH DENSITY POLYETHELYNE PLASTIC PIPE (HDPE), SCHEDULE 40, Based on Outside Diameter:

1. High density polyethylene heavy wall (HDPE-40) suitable for direct burial. 1” minimum size.

2. Fittings shall be threaded or heat welded type of same material as conduit. No splices are allowed underground due to high water table.
3. Approved for underground direct burial, May be used where buried in earth under floor slabs. Minimum depth of bury under slab shall be 18 inches or of sufficient depth to allow for bending radius to rise out of the slab vertically. Shall have an exposed grounding electrode conductor in each trench.
4. Not approved for above grade installation nor for embedding in concrete slabs. Not approved for elbows or risers above 22.5 degree bend.

G. PVC COATED GALVANIZED RIGID METAL CONDUIT (PGRC): NEMA RN 1.

1. Rigid galvanized conduit, prior to plastic coating, shall conform to ANSI Standard C80.1, UL 6, and CSA Standard C22.2 #45.

2. Nominal thickness of exterior PVC coating shall be 40 mils. A two-part red urethane coating of 2 mil thickness shall be applied to the interior of all conduits and fittings.

3. All hollow conduit fittings which serve as part of the raceway system shall be coated with exterior PVC coating and red interior urethane coating as described above.

4. Coated conduit shall conform to NEMA Standard No. RN1-1989. Shall be "Plastic-Bond Red" as manufactured by Robroy Industries, Inc.

   a. Approved Locations: Shall be used in all locations where conduits are buried, in contact with earth, and in wet and corrosive areas of the plant, and as noted on the drawings. All buried conduit between VFDs and motors. All risers through concrete floors.

H. LIQUIDTIGHT FLEXIBLE METAL CONDUIT: UL 360.

1. Galvanized steel with an extruded liquidtight PVC cover that is moisture and oil-proof, and UV resistant.

2. Fittings shall be liquidtight compression type, listed for grounding. Provide fittings with external bonding jumper where required for bonding.

3. Approved for flexible connections to equipment subject to vibration such as motors, fan, pumps, dry transformers, etc., 36-inch maximum, 18" minimum length for each connection.

I. FLEXIBLE METAL CONDUIT: UL 1.

1. Galvanized steel.

2. Approved for flexible connections to equipment in unclassified areas of the Administration Building.

J. RIDGED ALUMINUM CONDUIT:

Couplings shall be threaded type of same material and finish as conduit. Connectors shall be Myers hubs or equal of same material and finish as conduit.
Approved Locations: Interior where exposed, on the exterior exposed to moisture or corrosive atmosphere. Approved for above grade installation. May be used within the process area of the
plant.

K. CONDUIT BODIES:

1. Form 7 malleable iron with hot dip galvanized finish, PVC coated in wet or process areas of plant.
2. Gasketed cast iron, zinc plated cover with stainless steel screws.

PART 3 - EXECUTION

3.1 INSTALLATION OF ELECTRICAL RACEWAYS

A. General Requirements: Unless otherwise indicated, wiring shall consist of insulated conductors installed in conduits or raceways.

3.2 CONDUIT AND TUBING SYSTEMS

A. Conduit and tubing systems shall be installed as indicated. Conduit sizes are based on the use of insulated, copper conductors. Minimum size of raceways shall be as noted. Only metal conduits will be permitted when conduits are required for shielding or other special purposes indicated, or when required by conformance to NFPA 70. PVC coated rigid metal conduit will be used in damp, wet or corrosive locations and the conduit or tubing system will be provided with the appropriate boxes, covers, clamps, screws or other appropriate type of fittings. Any exposed threads or metal shall be touched up with 3 coats of touch up material provided with conduit. Raceways shall be kept 6" away from parallel runs of any mechanical piping. Raceways shall be concealed where possible. Raceways crossing structural expansion joints shall be provided with suitable expansion fittings and will provide continuity for grounding.

3.3 BELOW SLAB-ON-GRADE OR IN THE GROUND

A. All electrical wiring below slab-on-grade shall be protected by a conduit system. Conduit passing through slabs-on-grade shall be PVC coated rigid metal conduit. PVC conduits shall be installed below slab-on-grade or in the earth. All underground bends over 22º and risers through concrete slab shall be PVC coated GRC.

3.4 INSTALLED IN SLABS INCLUDING SLABS ON GRADE

A. Conduit shall not be embedded in concrete slabs except as specifically detailed.

3.5 EXPOSED RACEWAYS

A. Exposed raceways shall be installed parallel or perpendicular to walls, structural members, or intersections of vertical planes and ceilings. Raceways under raised floors and above ceilings shall be considered as exposed installations.

3.6 CHANGES IN DIRECTION OF RUNS

A. Changes in direction of runs shall be made with symmetrical bends or cast-metal fittings. Field made bends and offsets shall be made with an approved hickey or conduit bending machine. Crushed or deformed raceways shall not be installed. Trapped raceways in damp or wet locations shall be avoided where possible. Care shall be taken to prevent the lodgment of plaster, dirt, or trash in raceways, boxes, fittings and equipment during the course of construction. Clogged raceways shall be entirely freed from obstructions or shall be replaced.

3.7 SUPPORTS

A. Metallic conduits and tubing shall be securely and rigidly fastened in place at intervals of not more than 10' and within 3' of boxes, cabinets, enclosures, and fittings, with U-channel support systems, one hole conduit straps with clamp backs, and conduit hangers. All supports mounted in exterior, process, or exposed areas subject to corrosive atmosphere shall be stainless steel. Supports in other areas shall be hot dipped galvanized. C-clamps or beam clamps shall have strap or rod type retainers. Rigid plastic conduits (if permitted as wiring method) shall be supported as indicated above, except that they shall be supported at 3’-0” maximum on centers and as indicated in the NEC (NFPA 70). Loads and supports shall be coordinated with supporting structure to prevent damage or deformation to the structures, but no load shall be applied to joist bridging.

B. Fastenings shall be by wood screws or screw-type nails to wood; by toggle bolts on hollow masonry units; by expansion bolts on concrete or brick; by machine screws, welded threaded, heat-treated or spring-steel-tension clamps on steel work. Nail-type nylon anchors or threaded studs driven in by a power charge and provided with lock washers and nuts may be used in lieu of expansion bolts or machine screws. Raceways or supports shall not be welded to steel structures. Holes cut to a depth of more than 1-1/2 inches in reinforced concrete beams or to a depth of more than 3/4" in concrete joints shall avoid cutting the main reinforcement bars. Holes not used shall be filled. In partitions of light steel construction, sheet metal screws shall be used. Conduits shall not be supported using wire or nylon ties.

C. Raceways shall be installed as a complete system and shall be independently supported from the structure. Upper raceways shall not be supported of lower raceways. Supporting means shall not be shared between electrical raceways and mechanical piping or ducts and shall not be fastened to hung ceiling supports.

D. Support Installations:

1. U-channel supports generally are not detailed but must be adequate to support combined weights of conduit and conductors.
2. Clamps: Galvanized malleable iron one-hole straps with clamp backs, beam clamps or other approved device with necessary bolts, expansion shields. Perforated metal straps shall not be used.
3. Adjustable U-channel Supports: Used to support horizontal runs only, use trapeze hangers for parallel runs of conducts.
4. Surface mounted raceway bases shall be anchored to ceiling members or block walls on 5'-0" centers maximum spacing and at all junction and device boxes and at angle fittings. Anchors shall be: Expansion shields on concrete or solid masonry, toggle bolts on hollow masonry units or on suspended ceilings.

3.8 INSTALLATION OF RACEWAYS AND FITTINGS:

A. General:

1. All Conduit: In accordance with requirement of National Electrical Code and applicable local codes.

2. Steel Conduit: In accordance with recommendations of American Iron and Steel Institute "Design Manual on Steel Electrical Raceways," latest edition.

B. Electrical Continuity:

1. All metallic conduit systems shall be electrically continuous throughout.

C. Moisture:

1. All conduit systems shall be essentially moisture tight.

D. Alignment of Exposed Conduit:

1. Parallel with or at right angles to lines of structure.

E. Field Cuts and Threads:

1. Cuts shall be square, threads clean and sharp. Remove sharp or rough edges by reaming burrs. Before couplings or fittings are attached, apply one coat of red lead or zinc chromate to male threads of rigid steel conduit. Apply coat of red lead, zinc chromate or special compound recommended by manufacturer of conduit where conduit protective coating is damaged.

F. Bends:

1. Uniform, whether job-fabricated or made with standard fittings or boxes. Do not dent or flatten conduit.

2. Exposed Conduit: Symmetrical insofar as practicable.

G. Location:

1. Routing: Generally shown in schematic fashion, unless dimensioned or noted to contrary. Contractor shall determine actual routing as approved.

2. Conduit Not Shown: Contractor shall route as required to connect equipment as specified.

3. Vertical Risers, Equipment and Device Locations: Approximately as shown. Contractor shall coordinate installation of conduit, in locations indicated, with structure and equipment.

4. Conduit in Relation to Steam or Hot Water Lines or Other Hot Surfaces: Locate minimum of 6" away. If such separation is impracticable, protect from heat as approved.

H. Buried Conduit:

1. Depth of Burial: Minimum of 24" below finished grade with warning tape 12" above conduit.

I. Wall Penetrations: Required for passage of conduits installed by CONTRACTOR through walls, or partitions.

1. Penetrations Through Exterior Building Walls: Cast in sleeve/Core drill wall and provided conduit entrance seals as detailed. All penetrations shall be with rigid steel conduit PVC coated within the plant process areas.

2. Openings Required Through Existing Partitions: Shall be provided at CONTRACTOR's expense. Holes through masonry construction shall be cast/ drilled with suitable coring machine. Perform work neatly. Patches shall match original material in composition and appearance.

3. Provide fire seals where a fire rated partition or wall is penetrated.

J. Expansion Fittings:

1. Install in all conduit runs crossing structural expansion joint or in straight runs 75 feet or more in length.

K. Conduit Ends:

1. Cap spare conduits.

2. Open Conduit Ends Terminating in Switchboards, Cabinets or Similar Locations Where Exposed to Entrance of Foreign Material: Install insulating grounding bushing. Plug space around cables with sealing compound.

3. Cap or plug conduit ends to prevent entrance of foreign material during construction.

L. Conduit Connections:

1. Cabinets, Enclosures, and Boxes: Double lock nuts and insulating bushings for rigid conduits in unclassified areas, NEMA 1. Hubs for rigid conduits in damp, wet, exterior, or corrosive areas, NEMA 12, 3R, 4, 4X. Bushings, insulating type, bell ends, or insulated throat fittings shall be installed on the ends of all conduits. Grounding type fittings and bushings shall be utilized as required for bonding.

2. Metallic Conduit Terminating in Non-Metallic Manholes or Pull Boxes: Insulated grounding bushing with lay-in ground lugs.

3. Flexible conduit for connection to movable equipment shall be liquidtight, utilizing listed liquidtight fittings.

M. Cleaning:

1. Clean and swab inside of conduits by mechanical means to remove foreign materials and moisture before conductors are installed.

N. Spare Conduits:

1. Install nylon pull line for future installation of cables. Cap all conduits and mark where end is located on Record Drawings with dimensions.

END OF SECTION

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SECTION 16132
CONDUIT DUCTBANKS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish and install conduit ductbanks as required, and as shown on the Drawings. Materials employed shall be as indicated on the Drawings and specified herein. All exterior conduit shall be buried underground and embedded in sand as detailed.

1.2 SUBMITTALS

A. Submit product literature including manufacturer part number, model number, material, size, and specifications. Material shall not be installed until the Engineer has reviewed the submittal data.

B. Shop Drawings shall be submitted for review and acceptance showing routing, conduit size, and number and size of wires in each conduit before installation of conduit and any related work. Show proposed routing of conduits buried under floor slabs-on-grade, conduit and rebar embedded in floor slabs, columns, etc. Identify conduit by tag number of equipment served and by conduit schedule number.

1.3 QUALITY ASSURANCE

A. MATERIAL MANUFACTURERS: Firms regularly engaged in manufacture of duct system components of type and sizes required, whose products have been in satisfactory use in similar service for not less than (3) years.

B. STANDARDS: Comply with applicable portions of the NEMA standards pertaining to underground ducts. Comply with applicable portions of UL safety standards pertaining to electrical raceway systems; and provide products and components which have been UL listed and labeled. Comply with NEC requirements as applicable to construction of raceway systems.

1.4 APPLICABLE SECTIONS

A. Section “Earthworks”.

B. Section “Electrical General Requirements”.

C. Section “Conductors and Cables”.

PART 2 - PRODUCTS

2.1 DUCTS

A. Ducts shall be round-bore, size as indicated, Nonmetallic Conduit, HDPE-40 or PVC-40.

B. Duct elbows, bends, and off-sets above 22.5 degrees shall be fiberglass or pvc-coated GRC and shall at minimum be per the manufacturer’s requirements.

PART 3 - EXECUTION

3.1 CONDUIT BANKS

A. Each ductbank shall be completely encased in ~~red~~ uncolored bedding sand. Thickness of sand over, under and around ductbank shall be not less than 3 inches as detailed. All ductbanks shall include a grounding electrode conductor as detailed. Use red concrete if the site standard requires it.

B. Unless noted otherwise, the top of the concrete envelope shall be not less than 2'-6" below finished grade or paving. Absolute minimum burial of 18" below finished grade or paving.

C. Ducts shall be installed to provide a water-tight, continuous length duct. If required, joints in duct shall be as per the manufacturer's requirements, and staggered at least 6 inches.

D. Saddles shall be used for support as indicated on the drawings. Hold down anchors shall be provided as indicated and required to prevent duct from floating on wet concrete where applicable.

E. During construction, ends of ducts shall be plugged to prevent debris from entering into ducts. Particular care shall be taken to keep ducts clean of concrete or any other substance during the course of construction.

F. After each duct line has been completed, a mandrel not less than 12 inches long, having a cross section approximately 1/2" less than the inside cross section of the duct, shall be pulled through to clean out the duct of earth, sand or gravel.

G. Trenching, backfilling and surface repair shall be done in accordance with Division 2 of these specifications.

H. Ductbanks shall be straight without bends or off-sets where possible.

I. Over each ductbank at approximately 12 inches below grade, provide a detectable continuous red plastic warning tape to alert future excavators of the presence of the ductbank.

J. Provide nylon pull line in all ducts.

K. Coordinate trench requirements with existing and additional piping and utilities. Preserve and protect.

END OF SECTION

SECTION 16138
ELECTRICAL BOXES AND FITTINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish and install electrical boxes and electrical fittings as required, and as shown on the Drawings. Materials employed shall be as indicated on the specified herein.

B. Types of electrical boxes and fittings in this section include the following:
1. Outlet boxes
2. Junction boxes
3. Pull boxes
4. Conduit bodies
5. Bushings
6. Locknuts and hubs
7. Knockout closures
8. Miscellaneous boxes and fittings.

1.2 SUBMITTALS

A. Submit product literature including manufacturer, model or part number, materials of construction, size, ratings, and listings as a minimum.

1.3 QUALITY ASSURANCE

A. Comply with NEC as applicable to construction and installation of electrical boxes and fittings.

B. Comply with ANSI C 134.1 (NEMA Standards Pub No. OS 1) as applicable to sheet-steel outlet boxes, device boxed, covers and box supports. Provide electrical boxes and fittings, which have been UL listed and labeled.

PART 2 - PRODUCTS

2.1 FABRICATED MATERIALS

A. Flush Interior Outlet or Device Boxes: Provide one piece, galvanized flat rolled sheet steel interior wiring boxes of types, shapes and sizes, including box depths, to suit each respective location and installation; construct with stamped knockouts in back and sides, and with threaded screw holes with corrosion-resistant screws for securing box covers and wiring devices; minimum depth 1-1/2". Provide minimum 2-1/8" depth for boxes with three or more conduit entries.

B. Interior Outlet or Device Box Accessories: Provide box accessories as required for each installation, including mounting brackets, hangers, extension or plaster rings, fixture studs, cable clamps and metal straps for supporting boxes, which are compatible with boxes being used and fulfilling requirements of individual wiring applications.

C. Exposed Outlet or Device Boxes: Provide corrosion- resistant cast-metal type FD weatherproof wiring boxes of types, shapes and sizes (including depth) required, with integral threaded conduit hubs, face plates with spring-hinged waterproof caps suitable configured for each application, with face plate gaskets and corrosion-resistant fasteners.

D. Junction and Pull Boxes: Provide junction and pull boxes with covers of types, shapes and sizes to suit each respective location and installation; with welded seams and equipped with stainless hardware. Provide underground concrete junction boxes as required or indicated on the Drawings. Provide cast steel boxes with threaded hubs and gasketed cover as required or indicated on the Drawings.

E. Conduit Bodies: Provide galvanized cast-metal Form 7 conduit bodies of types, shapes and sizes to suit respective locations and installation, construct with threaded-conduit-entrance ends, removable covers, and corrosion-resistant screws.

F. Bushings, Knockout Closures, Locknuts, and Hubs: Provide corrosion-resistant punched-steel box knockout closures, conduit locknuts and hubs, and conduit bushings and offset connectors of types, and sizes to suit respective uses and installation.

G. All boxes, fittings, and conduit bodies shall be PVC coated wherever PVC coated conduits are required elsewhere in this specification.

PART 3 - EXECUTION

3.1 INSTALLATION OF ELECTRICAL BOXES AND FITTINGS:

A. General: Install electrical boxes and fittings where indicated, complying with manufacturer's written instructions, applicable requirements of NEC and NECA's "Standard of Installation", and in compliance with recognized industry practices to ensure that products fulfill requirements.

B. Coordinate installation of electrical boxes and fittings with wire/cable and raceway installation work.

C. Provide cover plates for all boxes. See Section “Wiring Devices”.

D. Provide weatherproof outlets for interior and exterior locations exposed to weather or moisture.

E. Provide knockout closures to cap unused knockout holes where blanks have been removed.

F. Install boxes and conduit bodies to ensure ready accessibility of electrical wiring. Install recessed boxes with face of box or ring flush with adjacent surface.

G. Fasten boxes rigidly to substrates or structural surfaces to which attached, or solidly embed electrical boxes in concrete or masonry. Use bar hangers for stud construction. Use of nails for securing boxes is prohibited. Set boxes on opposite sides of common wall with minimum 10" of conduit between them.

H. Provide electrical connections for installed boxes.

END OF SECTION

SECTION 16140
WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish and install wiring devices as required, and as shown on the Drawings. Materials employed shall be as indicated on the Drawings and specified herein.

1.2 SUBMITTALS

A. Submit product literature including manufacturer, model or part number, materials of construction, size, ratings, and listings as a minimum.

1.3 QUALITY ASSURANCE

A. NECA - Standard of Installation.

B. NEMA WD 1 - General Requirements for Wiring Devices.

C. NEMA WD 6 - Wiring Device -Dimensional Requirements.

D. NFPA 70 - National Electrical Code.

E. UL - Underwriters Laboratories, Inc.

PART 2 - PRODUCTS

2.1 WALL SWITCHES

A. Manufacturers:
   1. Hubbell, Model HBL-1221, 1223, 1224 series.
   2. Arrow Hart, Model 1991.

B. Description: NEMA WD 1, Heavy-Duty Specification Grade AC only general-use snap switch.

C. Body and Handle: Gray plastic with toggle handle.

D. Indicator Light: Lighted handle type switch red color handle.

E. Locator Light: Lighted handle type switch; red color handle.

F. Ratings:
   1. Voltage: 120-277 volts, AC.
   2. Current: 20 amperes.

2.2 RECEPTACLES

A. Manufacturers:
   1. Hubbell, Model HBL 5362-SP.
   2. Arrow Hart, Model 5362-CR.

B. Description: NEMA WD 1, Heavy-duty specification grade general use receptacle.

C. Device Body: Gray plastic.

D. Configuration: NEMA WD 6, type as specified and indicated.

E. Convenience Receptacle: Type 5-20.

F. GFCI Receptacle: Convenience receptacle with integral ground fault circuit interrupter to meet regulatory requirements.

2.3 WALL PLATES

A. Decorative Cover Plate: Brushed stainless steel in electrical/control/blower rooms.

B. Process Room/Exterior Cover Plate: Gasketed cast metal with hinged gasketed device cover. Lever type switch cover. Classified hazardous as required for process areas per drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that outlet or device boxes are installed at proper height.

B. Verify that wall openings are neatly cut and will be completely covered by wall plates.

C. Verify that branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.

3.2 PREPARATION

A. Provide extension rings to bring outlet boxes flush with finished surface.

B. Clean debris from outlet boxes.

3.3 INSTALLATION

A. Install in accordance with NECA "Standard of Installation."

B. Install devices plumb and level.

C. Install switches with OFF position down.

D. Install receptacles with grounding pole on bottom.

E. Connect wiring device grounding terminal to branch circuit equipment grounding conductor.

F. Install decorative plates on switch, receptacle, and blank outlets in finished areas.

G. Connect wiring devices by wrapping conductor around screw terminal.

H. Use jumbo size plates for outlets installed in masonry walls.

I. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible ceilings, and on surface mounted outlets.

3.4 INTERFACE WITH OTHER PRODUCTS

A. Install wall switch 48 inches above finished floor.

B. Install convenience receptacle 18 inches above finished floor unless otherwise indicated.

C. Install convenience receptacle 6 inches above back-splash of counter.

D. Install dimmer 48 inches above finished floor.

E. Install telephone/data jack 18 inches above finished floor.

F. Install telephone/data jack for side-reach wall telephone to position top of telephone at 54 inches above finished floor.

G. Install telephone/data jack for forward-reach wall telephone to position top of telephone at 48 inches above finished floor.

3.5 FIELD QUALITY CONTROL

A. Inspect each wiring device for defects.

B. Operate each wall switch with circuit energized and verify proper operation.

C. Verify that each receptacle device is energized.

D. Test each receptacle device for proper polarity.

E. Test each GFCI receptacle device for proper operation.

F. Verify that each telephone jack is properly connected and circuit is operational.

3.6 ADJUSTING

A. Adjust devices and wall plates to be flush and level.

3.7 CLEANING

A. Clean exposed surfaces to remove splatters and restore finish.

END OF SECTION

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SECTION 16155

EQUIPMENT WIRING

PART 1 - GENERAL

1.1 SCOPE

Furnish all labor, materials, equipment, appliances, and perform all operations in connection with, and complete in strict accordance with, this section of specifications and the applicable drawings and subject to the terms and conditions of the contract for the following work:

A. This section includes wiring connections to equipment specified in other sections.

B. Electrical connections to equipment: Provide the materials and make the electrical connections to all equipment having electrical requirements as indicated in the architectural and/or mechanical section of the specifications and drawings.

C. Provide conduit, wiring, connect motors and other mechanical equipment and electrical devices in other sections; also install, provide, support for, and connect starters, other control devices, control panels, furnished for such motors and equipment; complete all circuit leave in satisfactory operating conditions.

D. Provide control devices for equipment in addition to those furnished by the trades providing such equipment; refer to schedules on electrical and mechanical drawings for control devices to be furnished under scope of the electrical work.

E. Control devices and panels furnished by trades providing equipment will be delivered to electrician at site of project; acknowledge acceptance in writing; assume responsibility for particular installation before proceeding with installing and wiring them. Follow each manufacturer's printed installation directions and wiring diagrams for installing and making connections to his equipment and controls.

F. Consult contract drawings and specifications of trades providing equipment and controls, for control wiring diagrams, also refer to their shop drawings in order to become familiar with equipment type and operation of controls, their locations and extent of work required for installing, wiring and connecting them.

G. Starters for all motors requiring same shall be furnished by electrical contractor.

1.2 APPLICABLE SECTIONS

The General Conditions, Supplementary Conditions, Special Conditions, alternates, and addenda, applicable drawings, and the specifications including but not limited to the following:

A. Section “Electrical General Requirements”.

1.3 REFERENCES

A. Section “Quality Control”:

B. NEMA WD 1 - General Purpose Wiring Devices.

C. NEMA WD 6 - Wiring Devices - Dimensional Requirements.

D. NFPA 70 - National Electrical Code.

1.4 SUBMITTALS FOR REVIEW

A. Section Submittals: “General”.

B. Section Submittals: “Procedures for submittals”.

C. Product Data: Provide wiring device manufacturer's catalog information showing dimensions, configurations, and construction.

1.5 REGULATORY REQUIREMENTS

A. Conform to requirements of NFPA 70.

B. Products: Listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

1.6 COORDINATION

A. Obtain and review shop drawings, product data, manufacturer's wiring diagrams, and manufacturer's instructions for equipment furnished under other sections.

B. Determine connection locations and requirements.

C. Sequence rough-in of electrical connections to coordinate with installation of equipment.

D. Sequence electrical connections to coordinate with start-up of equipment.

PART 2 - PRODUCTS

2.1 CORDS AND CAPS

A. Manufacturers:
   1. Hubbell.
   2. Or equal.

B. Attachment Plug Construction: Conform to NEMA WD 1.

C. Configuration: NEMA WD 6; match receptacle configuration at outlet provided for equipment.

D. Cord Construction: NFPA 70, Type SJO multi-conductor flexible cord with identified equipment grounding conductor, suitable for use in damp locations.

E. Size: Suitable for connected load of equipment, length of cord, and rating of branch circuit over-current protection.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that equipment is ready for electrical connection, wiring, and energizing

3.2 ELECTRICAL CONNECTIONS

A. Make electrical connections in accordance with equipment manufacturer's instructions.

B. Make conduit connections to equipment using flexible conduit. Use liquid-tight flexible conduit with watertight connectors in damp or wet locations.

C. Connect heat producing equipment using wire and cable with insulation suitable for temperatures encountered.

D. Provide receptacle outlet to accommodate connection with attachment plug.

E. Provide cord and cap where field-supplied attachment plug is required.

F. Install suitable strain-relief clamps and fittings for cord connections at outlet boxes and equipment connection boxes.

G. Install disconnect switches, controllers, control stations, and control devices to complete equipment wiring requirements.

H. Install terminal block jumpers to complete equipment wiring requirements.

I. Install interconnecting conduit and wiring between devices and equipment to complete equipment wiring requirements.

END OF SECTION

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SECTION 16164

ELECTRIC ACTUATORS

PART 1 – General

1.0 THE REQUIREMENT

A. The Contractor shall furnish, test, install, and place into satisfactory operation the electric actuators, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.1 The actuators shall be suitable for use on a nominal 460 volt, 3 phase, 60Hz power supply and are to incorporate motor, integral reversing starter, local control facilities and terminals for remote control and indication connections housed within a self-contained, sealed enclosure.

1.2 As a minimum the actuators should meet the requirements set out in EN15714-2 and ISA SP96.02

1.3 In order to maintain the integrity of the enclosure, setting of the torque levels, position limits and configuration of the indication contacts etc. must be carried out without the removal of any actuator covers and without mains power over an Infrared or *Bluetooth®* wireless interface. Sufficient commissioning tools must be provided with the actuators and must meet the enclosure protection and certification levels of the actuators. Commissioning tools must not form an integral part of the actuator and must be removable for secure storage / authorized release. In addition, provision shall be made for the protection of configured actuator settings by a means independent of access to the commissioning tool. Provision shall be made to disable *Bluetooth®* communications or only allow a *Bluetooth®* connection initiated by an Infra-Red command for maximum security.

1.4 The actuator shall include a device to ensure that the motor runs with the correct rotation for the required direction of valve travel irrespective of the connection sequence of the power supply.

1.5 As manufactured by:

a. Rotork.

b. Bray.

c. Or approved equal.

PART 2 - Actuator Sizing

2.1 The actuator must be sized to guarantee valve closure at the specified differential pressure and temperature. The safety margin of motor power available for seating and unseating the valve must be sufficient to ensure torque switch trip at maximum valve torque with the supply voltage 10% below nominal. For linear operating valves, the operating speed shall be such as to give valve closing and opening at approximately 10-12 inches per minute unless otherwise stated in the data sheet. For 90° valve types the operating time will be specified.

PART 3 - Environmental

3.1 Actuators must be suitable for indoor and outdoor use with a standard corrosivity category, C4 medium durability as per ISO 12944. The actuator must be capable of functioning in an ambient temperature ranging from -30°C (-22°F) to +70°C (+158°F), up to 100% relative humidity. Actuators for hazardous area applications must meet the area classification, gas group and surface temperature requirements specified in the data sheet.

PART 4 - Enclosure

4.1 Actuators shall be O-ring sealed, watertight to IP66/IP68 20m for 10 days, NEMA 4, 6. The motor and all other internal electrical elements of the actuator must be protected from ingress of moisture and dust when the terminal cover is removed for site cabling. The terminal compartment must maintain the same ingress protection rating with the terminal cover removed. The actuator enclosure must allow for temporary site storage without the need for electrical supply connection. All external fasteners shall be suitable for the actuator corrosivity category and installation environment indicated on the datasheet.

PART 5 - Motor

5.1 The motor must be an integral part of the actuator, designed specifically for valve actuator applications. The motor shall be a low inertia, high torque design and class F insulated. Resulting in class B temperature rise with a time rating of 15 minutes at 40°C (104°F) at an average load of at least 33% of maximum valve torque. Temperature shall be limited by thermostat device embedded in the motor end windings and integrated into the actuator control. Electrical and mechanical disconnection of the motor shall be possible without draining the lubricant from the actuator gearcase. The actuator shall include a device to ensure that the motor runs with the correct rotation for the required direction of valve travel irrespective of the connection sequence of the power supply.

PART 6 - Motor Protection

6.1 Protection must be provided for the motor as follows:

- Stall - the motor must be de-energised within 8 seconds in the event of a stall when attempting to unseat a jammed valve.
- Over temperature - thermostat will cause tripping of the motor. Auto-reset on cooling
- Single phasing - lost phase protection.
- Direction – phase rotation correction.

PART 7 - Gearing

7.1 The actuator gearing must be totally enclosed in an oil-filled gearcase suitable for operation at any angle. Grease lubrication is not permissible. All drive gearing and components must be of metal construction and incorporate a lost-motion hammer blow feature. For rising spindle valves the output shaft shall be hollow to accept a rising stem, and incorporate thrust bearings of the ball or roller type at the base of the actuator. The design should be such as to permit the opening of the gearcase for inspection or disassembled without releasing the stem thrust or taking the valve out of service. For 90° operating type valves, drive gearing shall be self-locking to prevent the valve back-driving the actuator.

PART 8 - Hand Operation

8.1 A handwheel must be provided for emergency operation, engaged when the motor is declutched by a lever or similar means, the drive being restored to electrical operation automatically by starting the motor. The handwheel or selection lever must not move on restoration of motor drive. Provision shall be made for the hand/auto selection lever to be locked in both hand and auto positions. It should be possible to select hand operation while the actuator is running or start the actuator motor while the hand/auto selection lever is locked in hand without damage to the drive train.

8.2 Clockwise operation of the handwheel must give closing movement of the valve unless otherwise stated in the data sheet. For linear valve types the actuator handwheel drive must be mechanically independent of the motor drive and should be such as to permit valve operation in a reasonable time with a manual force not exceeding 400N through stroke and 800N for seating/unseating of the valve.

PART 9 - Drive Interface

9.1 The actuator shall be furnished with a drive bushing easily detachable for machining to suit the valve stem or gearbox input shaft. The drive bush shall be positioned in the base of the actuator. Thrust bearings shall be sealed for life and the base shall be capable of withstanding five times the rated thrust of the actuator.

PART 10 - Local Controls

10.1 The actuator must incorporate local controls for Open, Close and Stop operation and a Local/Stop/Remote mode selector switch. Mode selection must be lockable in any one of the following three positions: local control plus local stop only, stop (no electrical operation), remote control plus local stop only. It must be possible to select maintained or non-maintained local control.

10.2 The local controls shall be arranged so that the direction of valve travel can be reversed without the necessity of stopping the actuator.

10.3 The local controls and display shall be rotatable through increments of 90 degrees to suit valve and actuator orientation.

PART 11 - Torque and Limits

11.1 Torque and turns limitation to be adjustable as follows:

- Position setting range – multi-turn: 2.5 to 8,000 turns, with resolution to 7.5° of actuator output.
- Position setting range – direct drive part turn actuators: 90° +/-10°, with resolution to 0.1° of actuator output.
- Torque setting: 40% to 100% rated torque.

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11.2 Position measurement – Absolute position measurement should be incorporated within the actuator. The technology must be capable of reliably measuring position even in the case of a single fault. The design must be simple with the minimum amount of moving parts (no more than 5). Technologies such as LEDs or potentiometers for position measurement are considered unreliable and therefore not preferred.

11.3 Measurement of torque for multi-turn actuators must be from direct measurement of force at the output of the actuator. Methods of determining torque-using data derived from the motor such as motor speed, current, flux etc. are only acceptable for part-turn actuators.

11.4 A means for automatic “torque switch bypass” to inhibit torque off during valve unseating and “latching” to prevent torque switch hammer under maintained or repeated control signals shall be provided.

11.5 The electrical circuit diagram of the actuator should not vary with valve type remaining identical regardless of whether the valve is to open or close on torque or position limit.

PART 12 - Remote Valve Position and Status Indication

12.1 Four contacts must be provided which can be selected to indicate any position of the valve; Provision must be made for the selection of a normally closed or open contact form. Contacts shall maintain and update position indication during handwheel operation when all external power to the actuator is isolated.

12.2 The contacts must be rated for 5mA to 5A, 120V AC, 30V DC.

12.3 As an alternative to providing valve position indication, any of the four contacts shall be selectable to signal one of the following:

- Valve opening, closing or moving
- Thermostat tripped, lost phase
- Motor tripped on torque in mid travel, motor stalled
- Remote selected, Local selected, Stop selected
- Actuator being operated by handwheel
- Actuator fault

12.4 Provision shall be made in the design to support an additional eight contacts with the same configurable functionality.

12.5 A configurable monitor relay must be provided as standard, which can be used to indicate either Availability or Fault. The relay should be a spring return type with a Normally Open / Normally Closed contact pre-wired to the terminal block.

12.6 The Monitor (availability or fault) relay, being energized from the control transformer will de-energise under any one or more the following conditions:

12.7 Available Mode	Fault Mode
• Loss of main or customer 24V DC power supply	• Loss of main or customer 24V DC power supply
• Actuator control selected to local or stop	• Motor thermostat tripped
• Motor thermostat tripped	• Actuator internal fault
• Actuator internal fault	

12.8 Provision shall be made in the design for the addition of a contactless transmitter to give a 4-20mA analogue signal corresponding to valve travel and / or torque for remote indication when required. The transmitter will auto range to the set limits

PART 13 - Local Position Indication

13.1 The actuator display must include a dedicated numeric/symbol digital position indicator displaying valve position from fully open to fully close in 0.1% increments. Valve closed and open positions shall be indicated by symbols showing valve position in relation to the pipework to ensure that valve status is clearly interpreted. With mains power connected, the display must be backlit to enhance contrast at all ambient light levels and must be legible from a distance of at least 5m (16ft). A power save mode shall be available to switch off the display backlight during long periods of inactivity.

13.2 Red, green, and yellow LEDs corresponding to open, closed and intermediate valve positions must be included on the actuator display when power is switched on. The yellow LED should also be fully programmable for on/off, blinker and fault indication. The digital display must be maintained and updated during handwheel operation when mains power to the actuator is isolated.

13.3 The actuator display shall include a fully configurable dot-matrix display element with a minimum pixel resolution of 168 x 132 to display operational, alarm, configuration and graphical datalogger information. The text display shall be selectable between English and other languages such as: Spanish, German, French, and Italian. Provision shall be made to upload a different language without removal of any covers or using specialized tools not provided as standard with the actuator.

13.4 Datalogger graphical displays and trend graphs must be available on the local LCD for the following functions:

- Torque versus Position
- Number of Starts versus Position
- Number of starts per hour
- Dwell Time
- Average temperature

13.5The main display must include configurable a minimum of four different home-screens that include the following information:

- Position and status
- Position and torque (analogue)
- Position and torque (digital)
- Position and demand (positioning)

13.6 An optional environmental cover to protect the display from high levels of UV radiation or abrasive materials must be available and shall be fitted without the need for any special tooling.

13.7 The local controls and display must be rotatable through increments of 90 degrees to suit valve and actuator installation orientation.

PART 14 - Integral Starter and Transformer

14.1 The reversing starter, control transformer and local controls must be integral to the valve actuator and suitably housed to prevent breathing and condensation. The starter shall be suitable for 60 starts per hour during normal service or 1,200 starts per hour under reduced load conditions and of rating appropriate to motor size. The controls supply transformer shall be fed from two of the incoming three phases and incorporate overload protection. It must have the necessary voltage tapping and be adequately rated to provide power for the following functions:

- Energizing of the contactor coils
- 24V DC or 110V AC output for remote controls (maximum 5W/VA)
- Supply for all the internal electrical circuits

14.2 An alternative solid state motor starter is permissible for applications requiring up to 1,200 starts per hour. 24VDC remote controls should be used in combination with a solid state starter to maximise response time. The solid state starter must facilitate configurable electrical braking functionality.

14.3 Speed adjustable actuators must have an integral motor controller to manage starting, speed and operation.

PART 15 - Remote Control Facilities

15.1 The necessary control, wiring and terminals must be contained within the actuator enclosure. Open and close external interlocks must be made available to inhibit local and remote valve opening / closing control. It must be possible to configure the interlocks to be active in remote control only. Remote control signals fed from an internal 24VDC (or 110VAC) supply and/or from an external supply between 20V and 60VDC or 40V and 120VAC, must be suitable for any one or more of the following methods of control:

- Open, Close and Stop control
- Open and Close maintained or “push to run” (inching) control
- Overriding Emergency Shut-Down; to close (or open) valve from a normally closed or open contact
- Two-wire control; energise to close (or open), de-energise to open (or close)

15.2 Additionally, provision shall be made for a separate ‘drive enable’ permissive input to prevent any unwanted electrical operation.

15.3 It must be possible to reverse valve travel without the necessity of stopping the actuator or moving through an intermediate stop control position. The motor starter must be protected from excessive current surges during rapid travel reversal. The internal circuits associated with the remote control and monitoring functions are to be designed to withstand simulated lightning impulses up to 2kV.

15.4 Operation by distributed control system must be possible utilising one or more of the following network systems:

- Profibus
- Modbus
- Foundation Fieldbus
- DeviceNet
- Pakscan
- HART

PART 16 - Monitoring Facilities

16.1 Facilities to indicate actuator availability and monitor operation must be included as standard.

16.2 Actuator text display indication of the following status/alarms:

- Closed Limit, open limit, moving open, moving closed, stopped
- Torque trip closing, torque trip opening, motor stalled

- ESD active, interlock active
- Thermostat trip, phase lost, 24V supply lost, local control failure
- Configuration error, position sensor failure, torque sensor failure
- Battery low, battery discharged, power loss inhibit

16.3 Integral datalogger to record and store the following operational data:

- Opening last / average torque against position
- Closing last / average torque against position
- Opening motor starts against position
- Closing motor starts against position
- Total open / closed operations
- Maximum recorded opening and closing torque values
- Event recorder logging operational conditions (valve, control and actuator)

16.4 The event log must include time and date information for each stored event.

A. Logged data must be accessible via non-intrusive *Bluetooth®* communication and also visible on the actuator display. An intrinsically safe portable tool must be provided to extract datalogger and actuator configuration files from the actuator. The portable tool must permit *Bluetooth®* connection with a PC to perform file transfer. The actuator manufacturer must supply PC software to enable extracted actuator files to be viewed and analysed.

PART 17 - Wiring and Termination

17.1 Internal wiring shall be tropical grade PVC insulated stranded cable of appropriate size for the control and power. Each wire shall be clearly identified at both ends. The terminals shall be embedded in a terminal block of high tracking resistance compound.

17.2 The terminal compartment must be separated from the inner electrical components of the actuator by means of a watertight seal. A minimum of four threaded cable entries with provision for an additional four extra conduit entries must be available to accommodate wiring connections.

17.3 All wiring supplied as part of the actuator must be contained within the main enclosure for physical and environmental protection. External conduit connections between components are not acceptable. A durable terminal identification card showing a plan of terminals must be attached to the inside of the terminal box cover indicating:

- Serial number
- External voltage values
- Wiring diagram number
- Terminal layout

17.4 The code card must be suitable for the contractor to inscribe cable core identification alongside terminal numbers.

PART 18 - Commissioning Kit

18.1 Each actuator must be supplied with a start-up kit comprising installation instruction manual, electrical wiring diagram and cover seals to make good any site losses during the commissioning period. In addition, sufficient actuator commissioning tools shall be supplied to enable actuator set up and adjustment during valve/actuator testing and site installation commissioning.

PART 19 - Performance and Test Certificate

19.1 Each actuator must be performance tested by the manufacturer and individual test certificates are to be supplied free of charge. Test certificates must be retained by the manufacturer for the serviceable life of the product. The test certificate must include details of the equipment specification such as:

- Serial number

- Test date
- Manufacturing site address
- Customer
- Customer order number (where applicable)
- Actuator size
- Mounting flange
- Enclosure type
- Lubricant
- Paint coating
- Power supply
- Operating speed/time
- Drive close direction
- Gear ratio for second stage gearbox (where applicable)
- Electrical optional extras
- Catalogue performance

19.2 The test equipment should simulate a typical valve load. The following parameters must be recorded and clearly stated on the certificate:

- Torque at maximum torque setting in both directions
- Current at maximum torque setting in both directions
- Flash test statement
- Test power supply voltage

END OF SECTION

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SECTION 16174
ELECTRICAL MOTORS

PART 1 - GENERAL

1.1 SCOPE

A. This section specifies alternating current induction motors 300 horsepower and less to be provided with the driven equipment. This section refers to motors by the enclosure type as defined in NEMA MG 1. Compliance by the supplier to the requirement of the specification does not relieve them of responsibility of furnishing motors and motor accessories that are suitable for the specified service conditions.

1.2 QUALITY ASSURANCE

A. General
   1. Motors shall be built in accordance with UL 1004, NEMA Standard MG 1, and to the requirements specified herein.

B. References
   1. This section references the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
FORM A-1 1	Motor Data Sheet
IEEE 85	Test Procedure for Airborne Sound Measurements on Rotating Machinery
NEMA ICS 6	Enclosure for Industrial Controls and Systems
NEMA MG 1	Motors and Generators
UL 1004	Motors, Electric
NEC	National Electric Code, Latest Edition

1.3 SUBMITTAL DATA

A. Complete motor data shall be submitted with the driven machinery submittals. Motor data shall include.
   1. Machine tag and loop number, as identified in the P&IDs, and specifications number of driven machine.
   2. Motor manufacturer.
   3. Motor Type or model and dimension drawing.
   4. Nominal horsepower at installed altitude.
   5. Nominal efficiency.
   6. NEMA design.
   7. Frame size.
   8. Enclosure.
   9. Winding insulation class and treatment.

10. Rated ambient temperature.
11. Service factor.
12. Voltage, phase, and frequency rating.
13. Full load current at rated horsepower for application voltage.
14. Starting code letter, or locked rotor KVA, or current.
15. Special winding configuration such as part winding, star-delta.
16. Rated full load speed.
17. Power factor at full load.
18. Power and connection requirements of motor winding heaters.
19. Temperature protective devise ratings and connection information.
20. Recommended maximum size power factor correction capacitor.
21. Motor insulation dielectric withstand rating.
22. If driven from a variable frequency drive:
    a. Certification that the motor meets the requirements of NEMA MG-1 1993 part 31.
    b. Certification that the motor and mechanical drive are matched in design and suitable for use together for the specific installation and driven equipment conditions.

B. The OWNER/CONTRACTOR shall complete the motor data sheet at the end of this Section for each and every motor supplied, and submit the completed forms to the ENGINEER for review, as part of the submittal package for each piece of equipment.

C. Motor insulation resistance test report.

1.4 SERVICE CONDITIONS

A. Environmental Conditions
   1. All motors are subject to hose directed spray and up to a temperature 40°C. Motors shall be totally enclosed unless otherwise specified and shall be rated for service at elevation 4,300 feet above mean sea level or the elevation of the installation, whichever is most correct. Motors shall meet the criteria as specified in NEMA MG 1 for usual environmental conditions.

B. Operating Conditions
   1. Motors shall be selected for the operating conditions of the driven equipment in accordance with NEMA MG 1. Motors shall be subject to the vibration performance limits as follows:
      a. The rotor shall be dynamically balanced according to NEMA Standards. Balance limits shall be 1/2 the limits shown on NEMA MG 1-12.06. The depositing of metal on the rotor (solder, weld, etc.) to achieve balance is not acceptable. Pavement metal is to be removed to achieve a balance only without effecting the structural strength of the rotor. Chiseling or sawing parent metal is prohibited. The addition of weights is acceptable.

1.5 PERFORMANCE REQUIREMENTS

A. Motors shall be continuous duty of the type generally described as having normal starting torque with low current, NEMA design “B”.

B. Starting current for fully loaded motors shall be as defined by NEMA design “B”.

C. Motors shall be sized for operation at their respective horsepower rating, never at their service factor rating. All motors shall be rated with a service factor of at least 1.15.

D. The motor must develop sufficient locked rotor torque to provide breakaway of the load and to provide adequate torque during the acceleration period to overcome the load and inertial forces.

E. Acceleration time must be short enough to be within the thermal limits of the motor, but not so short that it over stresses the driven equipment.

F. Overhung load requirements such as the number and pitch radius of the motor-shaft-mounted pulley sprocket, etc., and the distance from the motor front bearing to the center of the pulley, sprocket, etc. must be determined and included in the purchase order.

G. Motors are to be manufactured with multiple dips of Class H varnish in order to accommodate the application of adjustable speed drive systems voltage and severe duty environments.

H. All equipment manufacturers shall provide a totally enclosed fan cooled motor, corrosion resistant and rated for severe, continuous duty operation.

I. Motors shall operate successfully at rated load under the various combinations of voltage and frequency variations specified in section 12.44 of NEMA MG1-1998.

J. Motors shall operate successfully under running conditions at rated load and frequency when the voltage unbalance at the motors terminals does not exceed 1%.

K. Motor balance and vibration shall meet NEMA standards as defined in MG1-1998 part 7. The motor shall be dynamically balanced to meet 0.08 in/s maximum velocity at the bearing housing when measured in the horizontal, vertical and axial plane (0.12 in/s on 2-pole motors frame 280 and above).

L. Unless otherwise specified in the equipment description, the motor rotation shall be possible in either direction – application permitting. See motor data sheet.

1.6 MOTOR CONSTRUCTION

A. Mechanical and Electrical Features:

1. All motors ¼ Hp through 2 Hp may have either NEMA C-Face or floor mounted feet, or both. Motors above 2 Hp shall be foot mounted in preference to any other method. Mounting requirements are provided in the horsepower descriptive section of the documents.

2. All motors controlled by a variable speed drives shall be equipped with motor shaft ground rings.
3. Long shaft motors are preferred over short shaft for close-coupled applications. Shafts shall have Impro seal supplied on both bearings. Motor shaft diameter shall comply with NEMA standard size for the motor frame size specified. Reduced, custom, or special shaft diameter motors are not acceptable unless specifically required by the application and approved, in writing, by project engineer. Notification of such variance must be submitted with bid proposals.
4. Motor speeds are dictated in the equipment descriptive documents included with this specification.
5. The following NEMA frame size shall be provided unless specifically approved by the project engineer (3600, 1800, 1200 & 900 RPM):
    a. 1 Hp through 2 Hp on a 143 T(C) to 213 T (C).
    b. 3 Hp through 5 Hp on a 182 T(C) to 254 T (C).
    c. 7.5 Hp through 10 Hp on a 213 T(C) to 284 TS
    d. 15 Hp through 25 Hp on 254 T to 326TS
    e. 30 Hp through 50 Hp on 286T to 404T
    f. 60 Hp through 100 Hp on a 364 T to 445T
    g. 125 Hp through 300 Hp on a 445TS to 5010 US
    h. Above 200 Hp, frame selection shall be defined on equipment data and motor data sheets.
6. Stator frame, end brackets, fan cover and conduit box shall be manufactured of high 25 grade cast iron. All frames shall be designed and constructed such that on direct-coupled applications the motor can be mounted and aligned without distortion of the feet, and sufficient strength to withstand overhung loads for belt drive applications. The motor shall be designed with the capabilities for mounting the drive side vertically up or down as required by the application.
7. Ventilating fans shall be non-sparking bronze alloy or non-conductive nylon 66 materials. The ventilation shall be such that cool air is drawn in and hot air expelled to avoid mixing with the incoming air.
8. All motors 1 Hp to 250 Hp shall be rated and wired as 3 phase, 60 Hertz 460 volt operation. Exceptions to this requirement must be reviewed and authorized by the project engineer. If wired for 230/460 volt, a wiring diagram shall be illustrated on the inside of the conduit box or name plate.
9. Moisture inhibiting coating shall protect the rotor and stator. These coatings must match or exceed the anticipated full load thermal conditions, vibration, and shock electrical insulation ratings of the motor.
10. All cast iron motor parts shall be primed and painted with epoxy or polyester resin enamel or similar coatings for additional corrosion and moisture protection.
11. Motor stator and rotor steel shall be low-loss C-5 electrical grade silicon steel with interlamination insulation capable of withstanding a minimum of 1000 ^{o}F burnout. Stator random windings shall be copper and shall be insulated with class H insulation.
12. Bearings shall be either 300 series ball bearings or cylindrical roller bearings on the drive end and opposite drive end. Bearings shall be selected to provide a minimum L-10 life of 50,000 hours with an external load per NEMA MG 1-14 and a L-10 life of 100,000 hours in direct coupled applications. Bearing type shall be defined on the motor data sheet.

13. Bearings shall have a maximum of 45ºC rise at rated horsepower (50 ºC for 2-pole motors).
14. Bearings on frames 143T through 5010UZ shall be regreaseable with regreasing instructions labeled on the motors. The bearings found in frames 213T and larger shall have open bearings with cast iron inner bearing caps. If motor is to be operated by a variable frequency drive the manufacturer shall provide optional insulated bearings on both end of direct coupled motors. See motor data sheets for VFD motors.
15. The motor bearing housing shall have an extended automatic grease relief valve to effectively prevent bearings from being over-lubricated.
16. The motor nameplate shall have raised letters stamped on 304 stainless steel and be fastened to the motor frame with four stainless steel drive pins.
17. All motor hardware shall be English type and grade 5 zinc-dichromate plated.
18. The winding insulation system shall be Class H or better, non-hygroscopic, chemical, corrosion, fungus and humidity resistant. The complete insulation system will have a minimum resistance of 1.5 megohms after 168 hours of testing in a humidity chamber maintained at 100% relative humidity and 40º C ambient with both end bells removed. Motors used in adjustable speed drive applications shall have an insulation rating of 1860 vac peak with a 0.1 micro second rise time.
19. Motor leads shall be stranded copper, permanently identified on both ends and are brought out into the motor terminal box through a neoprene lead-positioning gasket with compression type terminal lugs. Each of the three leads shall be brought through a single hole into the conduit and termination box.
20. The conduit box shall be cast iron and threaded for rigid conduit connection. Conduit box shall be located at the F1 position of the motor unless otherwise noted on the motor data sheet. Conduit box volumes shall exceed the NEMA minimum standards by a minimum of 25% and boxes shall be able to rotate 90-degree increments. A bronze ground lug shall be provided in the conduit box.
21. A lifting eyebolt shall be provided for motor lifting (180 frame and larger). Eyebolt holes shall be threaded blind holes.
22. Motors shall be suitable for field configuration to any ceiling, wall, or floor mounting by rotating conduit box, end shield, and rotor – per application requirements (143T through 365T).
23. All motors shall meet the “NEMA Premium” efficiency requirements as outline by NEMA Table 12.12. Any deviation from this specification shall be received in writing from the project engineer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:
   1. Smith & Loveless
   2. General Electric Company
   3. Louis Allis (Division of MagneTek, Inc.)
   4. U.S. Motors Corporation
   5. Toshiba.

6. Reliance.
7. Baldor Gold Series.

B. The OWNER/CONTRACTOR shall assign to the designated equipment supplier the responsibility to select and supply suitable electric motors for the equipment. The choice of motor manufacturer shall be subject to review and acceptance by the ENGINEER. Such review will consider future availability of replacement parts and compatibility with driven equipment.

2.2 MOTORS LESS THAN ½ HORSEPOWER:

A. General
1. Unless otherwise specified, motors less than 1/2 horsepower shall be squirrel cage, single phase, and capacitor start induction run. Small fan motors may be split-phase or shaded pole type. Wound rotor or commentator type single phase motors are acceptable where its characteristics are necessary for the application. Conductors shall be copper.

B. Rating
1. Motors shall be rated for operation at 115 volts, single phase, 60 Hz, and shall be continuous-time rated in conformance with NEMA Standard MG 1-10.35. Dual voltage rated motors are acceptable if all leads are brought out to the conduit box.
1. Locked rotor current shall not be greater than specified in NEMA Standard MG1-10.36, Design “N”.

C. Enclosures
1. Unless otherwise specified, motors shall be totally enclosed.

D. Bearings
1. Motors shall be provided with sleeve-type or sealed ball bearings lubricated for 5 years normal use.

E. Insulation
1. Comply with NEMA 1-1.65.
1. Motors shall be furnished with Class F insulation, rated to operate at a maximum ambient temperature of 40ºC and at the altitude where the motors will be installed and operated, without exceeding temperature rise limits stated in NEMA MG 1-12.42 for a Class B insulation at ambient temperature of 40°C, and without using the service factor.

2.3 MOTORS 1/2 HORSEPOWER THROUGH 300 HORSEPOWER:

A. General
1. The nominal motor horsepower shall be adequate for the driven machine without infringement upon the motor service factor at the installed altitude and specified ambient conditions.

2. The motor horsepower shall be not more than the estimated maximum specified for each driven machine.
   a. If the estimated maximum horsepower specified is not adequate to satisfy the foregoing restriction or any other requirements of these specifications, the motor with the next larger horsepower shall be supplied at no additional cost to the OWNER.
   b. In addition, any changes caused by increase in motor horsepower shall be made by the OWNER/CONTRACTOR at no additional cost to the OWNER; such changes may involve circuit breakers, motor controllers, VFDs, motor and branch circuit and feeder conductors and conduit sizes, etc.
3. Some requirements of the Section may be excluded for motors which are part of valve operators, submersible pumps, or motors which are an integral part of standard manufactured equipment (i.e., non-NEMA mounting, common shaft with driven element), to the extent that such variation reflects a necessary condition of motor service or a requirement of the specified driven equipment.
4. Motor Voltage Ratings: The OWNER/CONTRACTOR is required to review the Electrical Drawings and Specifications and to furnish all motors with voltage and phase as shown on the electrical drawings.
   a. The OWNER/CONTRACTOR shall notify the ENGINEER of any discrepancy between any motor sizes indicated by the Drawings and specified elsewhere, and any requirements of the driven equipment and the availability of motors from the manufacturers listed above.
5. Special Requirements: The OWNER/CONTRACTOR shall refer to individual equipment specifications and the Drawings for special requirements such as motor part winding start, multi-speed windings, protective devices, auxiliary devices, etc.
6. Horizontal Motors Installed Outdoors: All horizontal motors which will be installed outdoors shall be totally enclosed, fan cooled (TEFC) severe duty and/or chemical duty rated with a Service Factor of 1.15 unless otherwise noted or if the area classification required a more stringent motor enclosure.
7. Horizontal Motors Installed Indoors: Unless otherwise specified, all horizontal motors which will be installed indoors shall be TEFC (totally enclosed fan cooled) with a service factor of 1.15 minimum.
   a. All motors larger than 1 HP, located in damp environment such as in pump and pipe galleries, tunnels, chemical feed and sludge areas, shall be severe duty and/or chemical duty rated complying with IEEE 45.
8. High Efficiency Motors: Motors with a nameplate rating of 5 HP and above shall be “premium efficiency” units. Criteria stated herein, apply to horizontal motors without exception and apply to vertical motors insofar as they are available at time of construction.
   a. Efficiency shall be determined by the test as set forth in IEEE 112, Method B.
   b. If the inrush current due to the high efficiency design of the motor exceeds the available settings of the motor circuit protector, the motor circuit protector may be changed to a thermal magnetic circuit breaker, with the permission of the ENGINEER, at no additional cost to the OWNER.
   1) If is the OWNER/CONTRACTOR’S responsibility to perform the motor starting requirement coordination, and to notify the ENGINEER of any discrepancies.

B. Three Phase Motors

1. All motors 1/2 HP and larger shall be three phases unless otherwise indicated on Drawings, or specified elsewhere.
1. Voltage: All three phase motors shall be suitable for operation on 208, 230 and 460 VAC, unless otherwise indicated on the electrical plans.
2. NEMA Design:
   a. Electric Motors shall be NEMA Design B, (except as noted in equipment specifications for motors controlled as variable speed operation and other special motors), constant speed squirrel-cage induction motors having normal starting torque with low starting current.
   b. In no case shall starting torque or breakdown torque be less than the value specified in NEMA MG 1.
   c. Starting kilovolt ampere per horsepower shall not exceed values as specified in NEMA MG-1-10.37.
   d. Motors shall be suitable for operation on the following starting mechanisms as shown on the drawings:
   1) Across the line.
   2) Reduced voltage solid state starter.
   3) Variable frequency drive-inverter duty rated.
   4) 2 speed 2 winding.
3. Insulation:
   a. Comply with NEMA 1-1.65.
   b. Motors shall be furnished with Class H insulation or with Class F insulation, rated to operate at a maximum ambient temperature of 40ºC and at the altitudes where the motors will be installed and operated, without exceeding temperature rise limits stated in NEMA MG1-12.42 for Class B insulation at a 40º C ambient, and without using the service factor.
4. Motor Bearings:
   a. Antifriction, re-greaseable, and filled initially with grease suitable for ambient temperature to 40ºC.
   1) Suitable for intended application and have AFBMA B-10 rating L-10 life of 60,000 hours or more.
   2) Bearing mounting shall be designed with easily accessible grease supply, flush, drain, and relief fittings using extension tubes where necessary.

C. Vertical Motors
1. Comply with the requirements for three phase motors except where the following requirements are more stringent.
1. Enclosure:
   a. All vertical motors installed outdoors shall have Weather Protected Type II (WPII) enclosures.
   b. All vertical motors installed indoors shall have Weather Protected Type I (WP I) enclosures.
2. All vertical motors shall have a Service Factor of 1.15.
3. Motor Bearings:
   a. Antifriction, oil lubricated, and filled initially with oil suitable for ambient temperatures to 40º C.
   1) Suitable for intended application and have AFBMA B-10 rating life of 60,000 hours or more.

2) Bearing mounting shall be designed with easily accessible oil supply, flush, drain, oil level gauge, and relief fittings using extension tubes where necessary.

b. Furnished with re-lubricate ball, spherical, roller, or plate type thrust bearings. Lubrication shall be per manufacturer’s recommendation for smooth operation and long life of the bearings.

2.4 COMPONENTS

A. Motor Enclosures:
1. Open Drip Proof:
a. Stamped steel conduit boxes.
b. 1.15 service factor at 40º C ambient.
2. Totally Enclosed Fan Cooled:
a. Cast iron conduit box.
b. 1.15 service factor at 40º C ambient
c. Tapped drain holes with Type 316 stainless steel plugs for frames 286T and smaller.
d. Automatic breather and drain devices for frames 324T and larger.
e. Upgraded insulation by minimum of 3 dips and bakes and sealer coat of epoxy or silicone.
3. Severe Duty:
a. Corrosion resistant type conforming to motors designated by manufacturer as:
1) Chemical Duty.
2) Mill and Chemical.
3) Custom Sever Duty.
4) Or similar applicable manufacturer’s quality designation.
b. 1.15 service factor at 40º C ambient.
c. Tapped drain holes with Type 316 stainless steel plugs for frames 286T and smaller.
d. Automatic breather and drain devices for frames 324T and larger.
e. 2 cycles of vacuum epoxy impregnation of the motor windings.

2.5 ACCESSORIES

A. Conduit Boxes
1. Horizontal motors 3 HP and larger, and all vertical motors, shall have split-type cast metal conduit boxes.
2. Boxes on motors other than open drip-proof shall be gasketed.
1. Boxes shall be furnished with the size and number of openings as required for the conduits indicated on the Drawings.
2. Boxes shall be rotatable through 360 degrees in 90 degree increments.
3. Shall be furnished with an integral equipment ground lug installed and sized as required for the conductors indicated on the Drawings.

B. Lifting Devices: All motors weighing 265 lb (120 Kg) or more shall have suitable lifting devices for installation and removal.

C. Space Heaters:

1. All motors 1 HP and larger shall be furnished with winding heaters where installed outdoors.
2. Space heater ratings shall be 120 volts, single-phase, unless otherwise shown.
3. Bring power leads for heaters into conduit box.

D. Nameplate:
1. All motors shall be fitted with a permanent, stainless steel nameplate indelibly stamped or engraved with:
   a. NEMA Standard motor data.
   b. Bearing description and lubrication instructions.
   c. Insulation class.
   d. Ambient temperature.
   e. Altitude rating.
   f. Power factor at full load.

2.6 CURRENT BALANCE

A. Current unbalance on polyphase motors shall not exceed the values tabulated below when motor is operating at any load within its service factor rating and is fed by a balanced voltage system:
1. Under 5 horsepower: 25 percent
2. 5 horsepower and above: 10 percent

2.7 OVER-TEMPERATURE PROTECTION

A. General
1. Over-temperature protection devices shall provide a normally closed contact rated NEMA ICS Class B1 50. Relays or solid state contacts which are required shall be provided in an enclosure on or near the motor. Relay enclosure shall be in accordance with NEMA ICS-6 and shall be NEMA 4 for all motors.

B. Requirements
1. Over temperature protection is not required for motors rated less than 25 horsepower.
2. Over temperature protection for motors rated 25 horsepower or greater but less than 200 horsepower shall be thermal switches, NEMA MG 1-12.57, Type 2.
3. Over temperature protection for motors rated 200 horsepower or greater shall consist of a minimum of six 100 OHM Platinum RTD's embedded in the motor windings, and one 100 OHM for each bearing. Wiring to an external junction box shall be provided. Motor supplier shall coordinate with motor controller supplier to ensure RTD's match Multilin 369 requirements.

2.8 SHAFT CURRENT PROTECTION

A. All motors coupled with a variable frequency drive (VFD) shall include a shaft grounding system. Acceptable systems include Mercotac Rotary Electrical Connectors, AEGIS SGR, or equal.

PART 3 - EXECUTION

3.1 TESTING

A. Each motor shall be given a routine commercial test as required by NEMA MG 1 to demonstrate that it is free from electrical or mechanical defects. Copies of routine test reports shall be submitted in the format specified by NEMA.

END OF SECTION

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SECTION 16200
DRY TYPE TRANSFORMERS

PART 1 - GENERAL

1.1 SCOPE

A. This Section consists of dry type transformers and related items necessary to complete the work indicated within the Contract Documents.

1.2 REFERENCES

A. NEMA ST 1 – Specialty Transformers (Except General – Purpose Type).

B. NEMA ST 20 – Dry Type Transformers for General Applications.

C. NETA ATS – Acceptance Testing Specifications for Electrical Power Distribution Equipment (International Electrical Testing Association).

D. NFPA 70 – National Electrical Code.

E. UL – Underwriters Laboratories, Inc.

1.3 SUBMITTALS

A. Product Data: provide outline and support point dimensions of enclosures and accessories, unit weight, voltage, kVA, and impedance ratings and characteristics, tap configurations, insulation system type and rated temperature rise.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water construction debris, and traffic.

B. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to transformer internal components, enclosure, and finish.

PART 2 - PRODUCTS

2.1 DRY TYPE TRANSFORMERS

A. Transformers shall be premium high efficiency quiet type with copper windings, and shall be installed where indicated on the Drawings. The primary winding of the transformers shall have two 2-1/2 percent taps above, and below normal.

B. The transformers shall have a BIL of 10 KV with a temperature class of 185 degrees C for transformers up to 25 KVA, and a temperature class of 220 degrees C for larger transformers.

C. The sound level shall not exceed 44 dBa measured at 5 feet from the transformer after installation. Core and coil assemblies 30 KVA and larger, shall be mounted on rubber vibration isolators, designed to reduce harmonics generated noise.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Set transformer plumb and level.

B. Use flexible conduit, 2 feet minimum length for connections to transformer case. Make conduit connections to side panel of enclosure.

C. Mount wall-mounted transformers using integral flanges or accessory brackets furnished by the manufacturer.

D. Mount floor-mounted transformers on vibration isolating pads suitable for isolating the transformer noise from the building structure.

E. Mount trapeze-mounted transformers as indicated.

F. Provide grounding and bonding in accordance with Division 16.

3.2 FIELD QUALITY CONTROL

A. Inspect and test in accordance with NETA ATS, except Section 4.

B. Perform inspections and tests listed in NETA ATS, Section 7.2.

3.3 ADJUSTING

A. Adjusting installed work.

B. Measure primary and secondary voltages and make appropriate tap adjustments.

END OF SECTION

SECTION 16233
STATIC UN-INTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.1 SCOPE

Furnish all labor, materials, equipment, appliances, and perform all operations in connection with, and complete in strict accordance with, this section of specifications and the applicable drawings and subject to the terms and conditions of the contract for the following work:

A. Stand alone cord and plug connected UPS systems.

B. Provide one shelf mounted UPS in each PLC cabinet (PLC-A, PLC-B, PLC-SH, PLC-FE).

C. Provide one UPS for each computer system (SCADA, Historian Server, HMI Directory Server).

1.2 APPLICABLE SECTIONS

The General Conditions, Supplementary General Conditions, alternates and Addenda, applicable drawings and the technical specification including but not limited to the following;

A. Section “Electrical General Requirements”.

B. Section “Conductors and Cables”.

1.3 REFERENCES

A. IEEE 519 - Guide for Harmonic Control and Reactive Compensation of Static Power Converters.

B. NEMA PE 1 - Un-interruptible Power Systems.

C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

D. NFPA 70 - National Electrical Code.

1.4 SUBMITTALS

A. Submit under provisions of Section 16 05 00.

B. Shop Drawings: Indicate electrical characteristics and connection requirements. Provide battery rack dimensions; battery type, size, dimensions, and weight; detailed equipment outlines, weight, and dimensions; location of conduit entry and exit; single-line diagram indicating metering, control, and external wiring requirements; heat rejection and air flow requirements.

C. Product Data: Provide catalog sheets and technical data sheets to indicate physical data and electrical performance, electrical characteristics, and connection requirements.

D. Manufacturer's Installation and Operating Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product. Include equipment installation outline, connection diagram for external cabling, internal wiring diagram, and written instruction for installation.

E. Manufacturer's Certificate: Certify that Products meet or exceed specified requirements.

1.5 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Section 16 05 00.

B. Operation Data: Description of operating procedures.

C. Maintenance Data: Description of servicing procedures; list of major components; recommended remedial and preventive maintenance procedures; spare parts list.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years experience.

1.7 REGULATORY REQUIREMENTS

A. Conform to requirements of NFPA 70.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under provisions of Section 16 05 00.

B. Accept Products on site in factory packing. Inspect for damage.

C. Protect equipment from extreme temperature and humidity by storing in a conditioned space.

D. Protect equipment from dust and debris by wrapping unit in dust tight cover and storing away from construction activity.

1.9 MAINTENANCE SERVICE

A. Furnish service and maintenance of un-interruptible power supply for one year from Date of Substantial Completion.

B. Include coverage of travel, labor, parts, and service.

1.10 WARRANTY

A. Provide two year warranty under the provisions of Section 16 05 00.

B. Warranty: Include coverage for batteries.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Liebert

B. Powerware/Eaton

C. APC

D. Substitutions: Under provisions of Section 16 05 00.

2.2 UN-INTERRUPTIBLE POWER SUPPLY

A. System Configuration: Non-redundant on-line, dual conversion type.

B. Components:

1. Battery.
2. Rectifier/charger to maintain battery charge and to provide input to inverter when utility power is available.
3. Inverter to provide power to load during normal operation.
4. Monitors, sensors, and control circuits.

C. Design Standards: IEEE 519 and NEMA PE 1.

2.3 SYSTEM RATINGS AND OPERATING CHARACTERISTICS

A. System Continuous Rating: 700 VA/490 W over entire battery voltage range at specified power factor. Maintain output voltage within specified limits at any load from full load to no-load.

B. Battery Capacity: Capable of operating at full load for 30 minutes.

C. Voltage Rating: 120 volts.

D. Input Voltage Operating Range: Plus or minus 10 percent.

E. Input Frequency Operating Range: 60 Hz.

F. Input Current Limit: Adjustable to maximum of 125 percent of that required to operate at full load with battery bank on float charge.

G. Harmonic Distortion of Input Current Wave Form: 5 percent maximum at full load.

H. Output Voltage Regulation.

I. The UPS shall include a plug-in load bypass switch which allows the replacement of the UPS without interrupting power to the load served.

2.4 BATTERY

A. Storage Battery: Heavy duty VRLA type industrial battery, designed for auxiliary power service. Provide battery with impact resistant plastic case. Provide cells with explosion proof vents, and ample space for plate growth without stressing container and cover.

B. Electrolyte Specific Gravity: No greater than 1.250 when full charged and measured at 77 degrees F (25 degrees C).

C. Ampere-Hour Rating: Sufficient to supply direct current to inverter for outage period specified, with inverter operating at full rated output, to a discharge limit of not less than 1.65 volts per cell.

2.5 CONTROLS AND INDICATORS

A. Indicators:

1. “On-Line”
2. “Fail”

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

3.2 FIELD QUALITY CONTROL

END OF SECTION

SECTION 16353

SURGE PROTECTION DEVICES

PART 1 – GENERAL

1.01 SCOPE

The Contractor shall furnish and install the Surge Protective Device (SPD) equipment having the electrical characteristics, ratings, and modifications as specified herein and as shown on the contract drawings. To maximize performance and reliability and to obtain the lowest possible let-through voltages, the ac surge protection shall be integrated into electrical distribution equipment such as switchgear, switchboards, panelboards, busway (integrated within bus plug), or motor control centers. Refer to related sections for surge requirements in:

1.02 RELATED SECTIONS

1. Section 16426A – Metal Enclosed Draw out Switchgear (Magnum DS) – Low Voltage
2. Section 16426B – Metal Enclosed Draw out Switchgear (DSII) – Low Voltage
3. Section 16428 – Switchboards – Low Voltage (Compartmentalized Feeders – Pow-R-Line *i*)
4. Section 16429 – Switchboards – Low Voltage (Group Mounted Feeders – Pow-R-Line C)
5. Section 16431 – Switchboards – Low Voltage (Commercial Metering)
6. Section 16466 – Busway – Low Voltage
7. Section 16470 – Panelboards
8. Section 16482A & B – Motor Control Centers – Low Voltage (Freedom and Advantage)

1.03 REFERENCES

9. SPD units and all components shall be designed, manufactured, and tested in accordance with the latest applicable standards

   A. ANSI/UL 1449 4th Edition or later

   B. ANSI/UL 1283 5th Edition or later (type 2 applications)

   C. IEEE C62.41.1

   D. IEEE C62.41.2

   E. IEEE C62.43-2005

   F. IEEE C62.45-2002

   G. IEEE C62.48-2005

   H. IEEE C62.62-2010

   I. UL 96A

J. NFPA 780

1.04 SUBMITTALS – FOR REVIEW/APPROVAL

10. The following information shall be submitted to the Engineer:

    A. Provide verification that the SPD complies with the required ANSI/UL 1449 4th Edition or later listing by Underwriters Laboratories (UL). Compliance may be in the form of a file number that can be verified on UL's website www.ul.org, the website should contain the following information at a minimum: model number, SPD Type, system voltage, phases, modes of protection, Voltage Protection Rating (VPR), and Nominal Discharge Current (In).

11. Where applicable the following additional information shall be submitted to the engineer:

    A. Descriptive bulletins

    B. Product sheets

1.05 SUBMITTALS – FOR CONSTRUCTION

12. The following information shall be submitted for record purposes:

    A. Final as-built drawings and information for items listed in Section 1.04 and shall incorporate all changes made during the manufacturing process

2.08 QUALIFICATIONS

13. The manufacturer of the electrical distribution equipment shall be the manufacturer of the SPD within the electrical distribution equipment.

14. For the equipment specified herein, the manufacturer shall be ISO 14001 and ISO 9001 or 9002 certified.

15. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of twenty-five (25) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

16. The SPD shall be compliant with the Restriction of Hazardous Substances (RoHS) Directive 2011/65/EU and have a visible label showing compliance.

17. The SPD shall be UL 1449 current edition listed, 20 kA nominal discharge current, Type 1 or Type 2 for use in UL 96A systems.

1.07 DELIVERY, STORAGE AND HANDLING

Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of manufacturer's instructions shall be included with the equipment at time of shipment.

1.08 OPERATION AND MAINTENANCE MANUALS

Operation and maintenance manuals shall be provided with each SPD shipped.

PART 2 – GENERAL

2.01 MANUFACTURERS

1. Match panel brand

2. Or prior approved equal.

The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features, and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

2.02 VOLTAGE SURGE SUPPRESSION – GENERAL

1. Electrical Requirements

A. Unit Operating Voltage – Refer to drawings for operating voltage and unit configuration.

B. Maximum Continuous Operating Voltage (MCOV) – The MCOV shall not be less than 115% of the nominal system operating voltage.

C. The suppression system shall incorporate thermally protected metal-oxide varistors (MOVs) as the core surge suppression component for the service entrance and all other distribution levels. The system shall not utilize silicon avalanche diodes, selenium cells, air gaps, or other components that may crowbar the system voltage leading to system upset or create any environmental hazards. End of life mode to be open circuit. Unit with end of life short-circuit mode are not acceptable.

D. Unit shall operate without the need for an external overcurrent protection device, and be listed by UL as such. Unit must not require external overcurrent protective device or replaceable internal overcurrent protective devices for the UL Listing.

E. Protection Modes – The SPD must protect all modes of the electrical system being utilized. The required protection modes are indicated by bullets in the following table:

	Protection Modes			
Configuration	L-N	L-G	L-L	N-G
Wye	●	●	●	●
Delta	N/A	●	●	N/A
Single Split Phase	●	●	●	●

High Leg Delta	●	●	●	●

F. Nominal Discharge Current (I_n) – All SPDs applied to the distribution system shall have a 20kA I_n rating regardless of their SPD Type (includes Types 1 and 2) or operating voltage. SPDs having an I_n less than 20kA shall be rejected.

G. ANSI/UL 1449 4th Edition Voltage Protection Rating (VPR) – The maximum ANSI/UL 1449 4th Edition VPR for the device shall not exceed the following:

Modes	208Y/120	480Y/277	600Y/347
L-N; L-G; N-G	700	1200	1500
L-L	1200	2000	3000

2. SPD Design

A. Maintenance Free Design – The SPD shall be maintenance free and shall not require any user intervention throughout its life. SPDs containing items such as replaceable single-mode modules, replaceable fuses, or replaceable batteries shall not be accepted. SPDs requiring any maintenance of any sort such as periodic tightening of connections shall not be accepted. SPDs requiring user intervention to test the unit via a diagnostic test kit or similar device shall not be accepted.

B. Balanced Suppression Platform – The surge current shall be equally distributed to all MOV components to ensure equal stressing and maximum performance. The surge suppression platform must provide equal impedance paths to each matched MOV. Designs incorporating replaceable SPD modules shall not be accepted.

C. Electrical Noise Filter – Each Type 2 unit shall include a high-performance EMI/RFI noise rejection filter. Noise attenuation for electric line noise shall be up to 50 dB from 10 kHz to 100 MHz using the MIL-STD-220A insertion loss test method. Products unable able to meet this specification shall not be accepted.

a. Type 2 units with filtering shall conform to UL 1283 5th Edition

b. Type 1 units shall not contain filtering or have a UL 1283 5th Edition Listing.

D. Internal Connections – No plug-in component modules or printed circuit boards shall be used as surge current conductors. All internal components shall be soldered, hardwired with connections utilizing low impedance conductors.

E. Monitoring Diagnostics – Each SPD shall provide the following integral monitoring options:

a. Protection Status Indicators - Each unit shall have a green / red solid-state indicator light that reports the status of the protection on each phase.

i. For wye configured units, the indicator lights must report the status of all protection elements and circuitry in the L-N and L-G modes. Wye configured units shall also contain an additional green / red solid-state indicator light that reports the status of the protection elements and circuitry in the N-G mode. SPDs that indicate only the status of the L-N and L-G modes shall not be accepted.

ii. For delta configured units, the indicator lights must report the status of all protection elements and circuitry in the L-G and L-L modes

iii. The absence of a green light and the presence of a red light shall indicate that damage has occurred on the respective phase or mode. All protection status indicators must indicate the actual status of the protection on each phase or mode. If power is removed from any one phase, the indicator lights must continue to indicate the status of the protection on all other phases and protection modes. Diagnostics packages that simply indicate whether power is present on a particular phase shall not be accepted.

b. Remote Status Monitor (optional) – The SPD must include Form C dry contacts (one NO and one NC) for remote annunciation of its status. Both the NO and NC contacts shall change state under any fault condition.

c. Audible Alarm and Silence Button (optional) – The SPD shall contain an audible alarm that will be activated under any fault condition. There shall also be an audible alarm silence button used to silence the audible alarm after it has been activated.

d. Surge Counter (optional) – The SPD shall be equipped with an LCD display that indicates to the user how many surges have occurred at the location. The surge counter shall trigger each time a surge event with a peak current magnitude of a minimum of 50 ± 20A occurs. A reset pushbutton shall also be standard, allowing the surge counter to be zeroed. The reset button shall contain a mechanism to prevent accidental resetting of the counter via a single, short-duration button press. In order to prevent accidental resetting, the surge counter reset button shall be depressed for a minimum of 2 seconds in order to clear the surge count total.

i. The ongoing surge count shall be stored in non-volatile memory. If power to the SPD is completely interrupted, the ongoing count indicated on the surge counter's display prior to the interruption shall be stored in non-volatile memory and displayed after power is restored. The surge counter's memory shall not require a backup battery in order to achieve this functionality.

F. Thermal MOV Protection

The unit shall contain thermally protected MOVs. These self-protected MOVs shall have a thermal protection element integrated with the MOV and a mechanical disconnect with arc quenching capabilities in order to achieve overcurrent protection of the MOV. The thermal protection assembly shall disconnect the MOV(s) from the system in a fail-safe manner should a condition occur that would cause them to enter a thermal runaway condition.

Fully Integrated Component Design – All of the SPD's components and diagnostics shall be contained within one discrete assembly. The use of plug in single-mode modules that must be ganged together in order to achieve higher surge current ratings or other functionality shall not be accepted.

G. Safety Requirements

The SPD shall minimize potential arc flash hazards by containing no single-mode plug in user serviceable / replaceable parts and shall not require periodic maintenance. SPDs containing items such as replaceable single-mode plug in modules, replaceable fuses, or replaceable batteries shall not be accepted. SPDs requiring any maintenance of any sort such as periodic tightening of connections shall not be accepted. SPDs requiring user intervention to test the unit via a diagnostic test kit or similar device shall not be accepted.

a. SPDs designed to interface with the electrical assembly via conductors shall require no user contact with the inside of the unit. Such units shall have any required conductors be factory installed.

2.03 SYSTEM APPLICATION

1. The SPD applications covered under this section include distribution and branch panel locations, busway, motor control centers (MCC), switchgear, and switchboard assemblies. All SPDs shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category C, B, and A environments.

2. Surge Current Capacity – The minimum surge current capacity the device is capable of withstanding shall be as shown in the following table:

Minimum surge current capacity based on ANSI / IEEE C62.41 location category			
Category	Application	Per Phase	Per Mode
C	Service Entrance Locations (Switchboards, Switchgear, MCC, Main Entrance)	250 kA	125 kA
B	High Exposure Roof Top Locations (Distribution Panelboards)	160 kA	80 kA
A	Branch Locations (Panelboards, MCCs, Busway)	120 kA	60 kA

2.04 LIGHTING AND DISTRIBUTION PANELBOARD REQUIREMENTS

1. The SPD application covered under this section includes lighting and distribution panelboards. The SPD units shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category B environments.

A. The SPD shall not limit the use of through-feed lugs, sub-feed lugs, and sub-feed breaker options.

B. SPDs shall be installed immediately following the load side of the main breaker. SPDs installed in main lug only panelboards shall be installed immediately following the incoming main lugs.

C. The panelboard shall be capable of re-energizing upon removal of the SPD.

D. The SPD shall be integral to the panelboard and connected directly to the bus. Alternately, an integral SPD can be connected to a circuit breaker for disconnecting purposes if a disconnect is required.

E. The SPD shall be included and mounted within the panelboard by the manufacturer of the panelboard.

F. The SPD shall be of the same manufacturer as the panelboard.

G. The complete panelboard including the SPD shall be UL67 listed.

2.05 SWITCHGEAR, SWITCHBOARD, MCC AND BUSWAY REQUIREMENTS

A. The SPD application covered under this section is for switchgear, switchboard, MCC, and busway locations. Service entrance located SPDs shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category C environments.

B. The SPD shall be of the same manufacturer as the switchgear, switchboard, MCC, or busway

C. The SPD shall be factory installed integral to the switchgear, switchboard, MCC, and/or bus plug at the assembly plant by the original equipment manufacturer

D. Locate the SPD on the load side of the main disconnect device, as close as possible to the phase conductors and the ground/neutral bar.

E. The SPD shall be connected through a disconnect (30A circuit breaker). The disconnect shall be located in immediate proximity to the SPD. Connection shall be made via bus, conductors, or other connections originating in the SPD and shall be kept as short as possible.

F. The SPD shall be integral to switchgear, switchboard, MCC, and/or bus plug as a factory standardized design.

G. All monitoring and diagnostic features shall be visible from the front of the equipment.

2.06 SERVICE ENTRANCE REQUIREMENTS

A. Service entrance located SPDs shall be tested and designed for applications within ANSI/IEEE C62.41 Category C environments. EXECUTION.

2.07 EXAMINATION

2.08 FACTORY TESTING

1. Standard factory tests shall be performed on the equipment under this section. All tests shall be in accordance with the latest version of NEMA, IEEE, and UL standards.

2.09 INSTALLATION

1. The installation of the SPD shall be factory installed integral to the distribution equipment. The Contractor shall install all distribution equipment per the manufacturer's recommendations, applicable electrical codes and the contract drawings.

2.10 WARRANTY

1. The manufacturer shall provide a ten (10) year warranty (15 year warranty with registration) that covers replacement of the complete unit from the date of shipment against any SPD part failure when installed in compliance with manufacturer's written instructions and any applicable national or local electrical code.

END OF SECTION

SECTION 16400
SERVICE AND DISTRIBUTION SYSTEMS

PART 1 - GENERAL

1.1 SCOPE

A. Provide all operations, methods, labor and equipment and provide and install all materials and incidentals necessary for the completion of the work as specified herein or included on the Drawings.

1.2 WORK INCLUDED

A. Electrical work required is indicated on the Drawings and specified herein and elsewhere includes, but is not necessarily limited to:
   1. Complete electrical distribution systems for power, control, and instrumentation as shown.
   2. Complete system of raceways, conductors, and equipment for all other auxiliary systems required. If noted, the equipment and wiring of these auxiliary systems will be furnished and installed under their respective sections; however, the conduit or raceway systems will be furnished and installed in accordance with Division 16.

B. The CONTRACTOR shall furnish and install all component parts of all the systems required for their safe and proper operation, whether or not specifically mentioned or noted on the Drawings, except those items or articles which are specifically noted as being supplied otherwise.

C. Perform all trenching and backfilling required in connection with the work which shall be in strict accordance with the provisions of Division 16 of these specifications.

D. Provide all required electrical conduits, conductors, and connections to items described in all other sections of these specifications.

1.3 APPLICABLE SECTIONS

A. The General Conditions, Supplementary Conditions, Special Conditions, Alternates and addenda, applicable drawings and the technical specifications herein shall apply.

B. Section “Distribution Panelboards”.

1.4 ELECTRICAL SERVICE

A. New underground electrical service(s) from the local utility shall be at 480/277 volt, three phase, four wire, 60 hertz AC with current ratings as indicated on the Drawings.

B. The installation shall be in accordance with the utility company’s published requirements. The CONTRACTOR shall coordinate the installation with the utility.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation of the service entrance sections shall be in accordance with the manufacture's requirements.

3.2 INSTALLATION OF GROUNDING ELECTRODE SYSTEM

A. The service entrance section shall be bonded to the grounding electrode system (GES). The GES consists of, but not limited to, the metal underground water pipes, metal frame of the building or structure, concrete encased electrode (UFER), ground rings, rods, pipe, or plate electrodes, and other metal underground systems or structures as in compliance with the NEC. Provide bonding jumper same size as system ground to provide ground continuity from customer's side of metallic lines service entrance and street side of metallic mains. The neutral (grounded conductor) and grounding electrode system shall be connected together at the service disconnect only.

B. The UFER ground system consists of a bare copper conductor, size as indicated in the Drawings, concrete encased 2" above the bottom of the foundation footing of the building or structure which is in direct contact with earth. The UFER ground will make a complete loop in the foundation and is bonded to the rebar steel at least in two locations. UFER ground connections shall be exothermic welds.

C. The equipment grounding system shall be such that all metallic structures, enclosures, raceways, junction boxes, outlet boxes, cabinets, machine frames, portable equipment and other conductive items in close proximity with the electrical circuits operate continuously at ground potential and provide a low impedance path for the possible ground fault currents. The system shall comply with the National Electrical Code, modified as indicated on the Drawings or specifications.

D. The distributions system shall be provided with a separate equipment grounding conductor for each single or three-phase feeder, each branch circuit, each motor circuit, control or instrument raceways as indicated. The grounding conductor shall be installed in the common raceway with the related phase and/or neutral conductors. Flexible conduit equipment connections utilized in conjunction with branch circuits or feeders shall be provided with suitable bonding jumpers connected to listed grounding type fittings when required.

3.3 TESTING

A. General: Upon completion of this portion of the work, test all parts of the electrical system in the presence of the ENGINEER.

B. Test Requirements: All systems shall test free from short circuits and grounds, shall be free from mechanical and electrical defects, and shall show an insulation resistance between phase conductors and ground of not less than that required by the manufacturers.

3.4 FINAL INSPECTION

A. The CONTRACTOR shall be present at the final acceptance of the work by the OWNER.

B. The CONTRACTOR shall have pad and pencil to list all deficient items noted. Corrections and adjustments of deficient items shall be done after the inspection, not during.

C. See Section for other requirements for final acceptance.

END OF SECTION

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SECTION 16401

PROCESS CONTROL & INSTRUMENTATION SYSTEM-GENERAL

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. General requirements applicable to all process control work.
2. The requirements of this Section apply to all components of the Software Systems unless indicated otherwise.
3. General requirements for programming submittals.

B. Related sections:

1. The Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the CONTRACTOR and its Subcontractors to review all sections to ensure a complete and coordinated project:
    a. Items involving electrical, control, and instrumentation construction may be shown on Drawings or referred to in Specifications that do not apply specifically to electrical, control and instrumentation systems.

C. The Programming Contractor shall program all PLC's and the SCADA system. The Programming Contractor shall provide all software as specified herein for programming the system. The Programming Contractor and the electrical contractor shall be responsible to test each device and loop to verify proper function of all equipment on the project, whether provided by the contractor or by the owner. They shall then work with the owner to test and commission the entire system as described herein. The programming contractor shall be present to test the I/O for each equipment subsystem. The I/O to the PLC systems shall be tested at this time. The programming contractor shall provide and install a simple testing routine in each PLC in order to verify all I/O is functioning properly. All I/O shall be tested from its respective field device to the software level in the PLC. If final PLC programming is complete at the time of testing, the final software programming shall be used to test each device

D. The Programming Contractor shall design the operator interface graphics, human machine interface (HMI) graphics, PLC logic, and control systems hardware as specified herein.

E. Contract Documents:

1. General:

a. Contract documents consist of drawings, specifications, and other documents issued by the ENGINEER. The Drawings and Specifications are complementary and are to be used together in order to fully describe the Work, and requirements shown, written or reasonably inferred there from on one is considered as written, shown or implied in all. In the event work is called for in more than one place and there are conflicting requirements, the right shall be reserved to require the installation of the larger or the more expensive.

b. Schematic Diagrams:

1) All controls are shown de-energized.

a) Schematic diagrams show control function only. Incorporate other necessary functions for proper operation and protection of the system.

b) Control schematics are to be used as a guide in conjunction with the descriptive operating sequences found in the Drawings or Specifications. Combine all information and furnish a coordinated and fully functional control system program.

1.2 <u>REFERENCES</u>

A. Code Compliance:

1. The publications are referred to in the text by basic designation only. The latest edition accepted by the Authority Having Jurisdiction of referenced publications in effect at the time of Bid governs

2. The following codes and standards are hereby incorporated into these Specifications:

a. National Fire Protection Association (NFPA):

1) NFPA 70 - National Electric Code (NEC).

2) NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.

3) NFPA 496 - Purged and Pressurized Enclosures for Electrical Equipment, where applicable.

4) NFPA 820 - Standard for Fire Protection in Wastewater Treatment and Collection Facilities.

b. Underwriters Laboratories, Inc. (UL):

1) UL 508 - Industrial Control Equipment.

c. American National Standards Institute (ANSI):

1) ANSI B16.5 - Pipe Flanges and Flanged Fittings.

d. American Petroleum Institute (API):

1) API RP551 - Process Measurement Instrumentation.

2) API RP552 - Transmission Systems.

3) API RP553 - Refinery Control Valves.

4) API RP554 - Process Instrumentation and Control.

5) API RP555 - Process Analyzers.

6) API RP556 - Fired Heaters & Steam Generators.

7) API RP557 - Guide to Advanced Control Systems.

e. American Society of Testing and Materials (ASTM):

1) ASTM A269 - Seamless and Welded Austenitic Stainless Steel Tubing for General Service.

f. Instrumentation, Systems, and Automation Society (ISA):

1) ISA-5.1 - Instrumentation Symbols and Identification.

2) ISA-5.2 - Binary Logic Diagrams for Process Operations.

3) ISA-5.3 - Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic, and Computer Systems.

4) ISA-5.4 - Instrument Loop Diagrams.

5) ISA-5.5 - Graphic Symbols for Process Displays.

6) ANSI/ISA-7.00.01 - Quality Standard for Instrument Air.

7) ISA-RP - 12.4 - Pressurized Enclosures.

8) ANSI/ISA-18.1 - Annunciator Sequences and Specifications.

9) ISA-20 - Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves.

10) ISA-TR20.00.01 - Specification Forms for Process Measurement and Control Instruments Part 1: General Considerations Updated with 27 New Specification Forms in 2004-2005.

11) ANSI/ISA-50.00.01 - Compatibility of Analog Signals for Electric Industrial Process Instruments.

12) ISA-51.1 - Process Instrumentation Terminology.

13) ISA-RP60.3 - Human Engineering for Control Centers.

14) ISA-71.01 - Environmental Conditions for Process Measurement and Control Systems: Temperature and Humidity.

15) ISA-71.02 - Environmental Conditions for Process Measurement and Control Systems: Power.

16) ISA-71.03 - Environmental Conditions for Process Measurement and Control Systems: Mechanical Influences.

17) ISA-71.04 - Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants.

1.3 DEFINITIONS

A. Definitions of terms and other electrical and instrumentation considerations as set forth in the:

1. National Electrical Code.
2. Institute of Electrical and Electronic Engineers.
3. Instrumentation, Systems, and Automation Society.
4. National Fire Protection Association.
5. National Electrical Testing Association.

B. Specific Definitions:

1. Control Circuit: Any circuit operating at 120 volts AC or DC or less, whose principal purpose is the conveyance of information (including performing logic) and not the conveyance of energy for the operation of an electrically powered device.
2. Panel: An instrument support system that may be either a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems. Unless otherwise specified or clearly indicated by the context, the term “panel” in these Contract Documents is interpreted as a general term, which includes flat surfaces, enclosures, cabinets and consoles.
3. Power Circuit: Any circuit operating at 90 volts (AC or DC) or more, whose principal purpose is the conveyance of energy for the operation of an electrically powered device.
4. Signal Circuit: Any circuit operating at less than 50 volts AC or DC, which conveys analog information or digital communications information.
5. Digital Bus: A communication network, such as Profibus, Foundation Fieldbus, or DeviceNet, allowing instruments and devices to transmit data, control functions and diagnostic information.
6. 2-Wire Transmitter (Loop Powered): A transmitter that derives its operating power supply from the signal transmission circuit and requires no separate power supply connections. As used in this Specification, two-wire transmitter refers to a transmitter that provides 4 to 20 mA current regulation of a signal in a series circuit with an external 24 VDC driving potential.
7. Field Bus Communications signal or both.
8. Powered Transmitters: A transmitter that requires a separate power source (120 VAC, 240 VAC, etc.) in order for the transmitter to develop its signal. As used in this Specification, the produced signal may either be a 4 to 20 mA current signal, a Digital Bus communications signal or both.
9. Modifications: Changing, extending, interfacing to, removing or altering an existing circuit.

C. Acronym Definitions:

1. ES: Enterprise System: Computer based communications or data sharing system utilized for non-process control functions such as E-mail, sharing files, creating documents, etc.
2. FAT: Factory Acceptance Test.

3. HOA: Hand-Off-Auto control function that is totally PLC based. In the Hand mode of control equipment is started or stopped, valves are opened or closed through operator direction under the control of the PLC software. In the Auto mode of control equipment is started or stopped, valves are opened or closed through a control algorithm within the PLC software. In the Off mode the equipment is prohibited from responding from the PLC control.
4. HMI: Human Machine Interface: PLC based operator interface device consisting of an alphanumeric display and operator input devices. The HMI is typically a flat panel type of display with either a touch screen or tactile button interface.
5. HVAC Heating, Ventilation, & Air Conditioning.
6. ICSC: Instrumentation and Control System Contractor: Subcontractor who specializes in the design, construction, fabrication, software development, installation, testing, and commissioning of industrial instrumentation and control systems.
7. IJB: Instrument Junction boxes. A panel designed with cord sets to easily remove, replace or relocate instrument signals.
8. I/O: Input / Output.
9. LCP: Local Control Panel: Operator interface panel that may contain an HMI, pilot type control devices, operator interface devices, control relays, etc. and does not contain a PLC or RIO.
10. LAN: Local Area Network: A control or communications network that is limited to the physical boundaries of the facility.
11. LOR: Local-Off-Remote control function. In the Remote mode equipment is started or stopped, valves are opened or closed through the PLC based upon the selection of the HOA. In Local control, equipment is started or stopped, valves are opened or closed based upon hardwired control circuits completely independent of the PLC with minimum interlocks and permissive conditions. In the Off mode, the equipment is prohibited from responding to any control commands.
12. OIT: Operator Interface Terminal. PC based interface device used for operator interface with the SCADA system.
13. P&ID: Process and Instrumentation Diagram.
14. PC: Personal Computer.
15. PCIS: Process Control and Instrumentation System, includes the entire instrumentation system, the entire control system, and all of the work specified in Division 17 and depicted on the Instrumentation Drawings.
16. PCM: Process Control Module: An enclosure containing any of the following devices: PLC, RIO.
17. PJB: Power Junction Box: An enclosure with terminal blocks that distribute power to multiple instruments.
18. PLC: Programmable Logic Controller.
19. RIO: Remote I/O device for the PLC consisting of remote I/O racks, or remote I/O blocks.

20. RTU: Remote Telemetry Unit: A controller typically consisting of a PLC, and a means for remote communications. The remote communications devices typically are radios, modems, etc.
21. SCADA: Supervisory Control and Data Acquisition system consists of the computer-based software system that includes the operator interface, data storage, data retrieval, archiving, alarming, historian, reports, trending, and other higher level control system software.
22. UPS Uninterruptible Power Supply.
23. VCP: Vendor Control Panel: Control panels that are furnished with particular equipment by a vendor other than the ICSC. These panels may contain PLCs, RIO, OIT, HMI, etc.
24. WAN: Wide Area Network: A control or communications network that extends beyond the physical boundaries of the facility.

1.4 SYSTEM DESCRIPTION

A. General Requirements:

1. The Work includes everything necessary for and incidental to executing and completing the general requirements for programming the control system described in the Contract Drawings and Specifications and reasonably inferable there from including but not limited to:
    a. Procure all software.
    b. With the electrical contractor, perform post programming tests on panels.
    c. With the electrical contractor, oversee, document, and certify system pre-commissioning.
    d. With the electrical contractor, conduct the Performance Tests.
    e. Prepare Operation and Maintenance Manuals.
    f. Conduct training classes.
    g. Develop all requisite loop descriptions, functional narrative and instructions and record drawings associated with the programs provided under other Divisions of these Specifications.
2. It is the intent of these Specifications that the programmed system be complete and operable.
3. Furnish detailed, complete, and thorough operations and maintenance documentation, including, but not limited to: Operations Manuals, Maintenance Manuals, Training Manuals, As-Built Software Documentation, final as installed software configurations, and software disks including installed program disk.

1.5 SUBMITTALS

A. General:

1. Furnish Submittals that are fully developed for a given section of the work and fully indexed with a tabbed divider for every element and component.

2. Sequentially number the pages within the tabbed sections. Submittals and Operation and Maintenance manuals that are not fully indexed and tabbed with sequentially numbered pages, or are otherwise unacceptable, will be returned without review.
3. Edit all Submittals and Operation and Maintenance Manuals so that the submittal specifically applies to only the equipment furnished. Neatly cross out all extraneous text, options, models, etc. that do not apply to the equipment being furnished, so that the information remaining is only applicable to the equipment being furnished.
4. Submittal Requirements:
    a. Submit copies of shop drawings, and product data, in accordance with the requirements of this Section:
        1) Show information on software to be supplied, SCADA screens, reports, menus, operation, etc.
5. Exceptions to Specifications and Drawings:
    a. Include a list of proposed exceptions to the Specifications and Drawings along with a detailed explanation of each.
    b. Any exceptions to the Specification and Drawings must be noted and the reason for the exception explained.
    c. If there is insufficient explanation for the deviation, the submittal will be returned requiring Revision and Re-submittal.
    d. Acceptance of any exception is at the sole discretion of the ENGINEER. Furnish all items (materials, features, functions, performance, etc.) that are not listed as exceptions strictly in accordance with the Specifications and Drawings.
    e. Replace all items that do not strictly meet the requirements of the Specifications, which were not previously accepted as exceptions, even if the Submittals contained information indicating the failure to meet the requirements.
6. Submittal Organization:
    a. First page:
        1) Specification Section reference.
        2) Name and telephone number of individual who reviewed submittal before delivery to ENGINEER.
        3) Name and telephone number of individual who is primarily responsible for the development of the submittal.
        4) Place for CONTRACTOR's review stamp and comments.
    b. Next pages:

1) Provide confirmation of Specification compliance in a tabular form that individually lists each Specification section, paragraph, and sub-paragraphs and unequivocally states compliance with said requirement or takes exception to the requirement and lists the reason for said exception and offers alternative means for compliance.

2) Include a response in writing to each of the ENGINEER's comments or questions for submittal packages which are re-submitted:

c. In the order that the comments or questions were presented throughout the submittal.

d. Referenced by index section and page number on which the comment appeared.

e. Acceptable responses to ENGINEER's comments are either:

f. ENGINEER's comment or change is accepted and appropriate changes are made.

g. Explain why comment is not accepted or requested change is not made.

h. Explain how requirement will be satisfied in lieu of comment or change requested by ENGINEER.

i. Any re-submittal, which does not contain responses to the ENGINEER's previous comments, shall be returned for revision and re-submittal.

j. No further review by the ENGINEER will be performed until a response for previous comments has been received.

k. Remaining pages:

1) Actual Submittal data:

a) Organize Submittals in exactly the same order as the items are referenced, listed, and/or organized in the Specification section.

b) For Submittals that cover multiple devices used in different areas under the same Specification section, the Submittal for the individual devices must list the area where the device is intended to be used.

l. Specific Submittal requirements:

1) Furnish the submittals required by each Section or Division 17:

a) Product Data.

b) Shop Drawings.

m. Furnish submittals in the following general order, each in a separate bound set:

1) Product Data.

2) After approval of the Product Data, submit the Project Shop Drawing submittals

3) Testing, Calibration and Start-up procedures.

4) Operation and Maintenance Data.

5) Training Submittals.

6) Record Documents.

B. Product Data:

1. General:

a. Submitted for non-custom manufactured material listed in this and other sections and shown on shop drawings.

b. Furnish sufficient information to evaluate the suitability of the proposed material or equipment for the intended use, and for compliance with these Specifications.

c. Include:

1) Catalog cuts.

2) Bulletins.

3) Brochures.

4) Quality photocopies of applicable pages from these documents.

5) Identify on the data sheets the project name, applicable specification section, and paragraph.

6) Identify model number and options for the actual equipment being furnished.

d. Neatly cross out options that do not apply or equipment not intended to be supplied.

2. Software Data Sheets and Cut Sheets:

a. Provide fully completed data sheets , in hardcopy, for each software package. Including the following information on the data sheet:

1) License limitations, points, screens available.

2) Description of software compatibilities with hardware (PLC's, ethernet communications, P.C.'s, modems, HMI's, etc.)

3) Description of software capabilities, function and use.

3. Software Program Submittal:

a. Prepare a program submittal to demonstrate how the programs address the following:

1) Alarm indication and notification.

2) Alarm acknowledgement.

3) Operational sequences.

4) Communications.

5) Recording and trending – show for each recorded or tended tag.

6) Report generation with samples.

7) Maintenance information and notes storage.

8) Samples of each screen shot and report.

C. Operation and Maintenance Manuals:

1. Furnish the ENGINEER with a complete preliminary set of written Operation and Maintenance Manuals 2 weeks before start-up and/or testing.
2. Furnish in accordance with the following additional requirements.
3. Submit preliminary sets of these manuals to the ENGINEER for review of format and content:
   a. ENGINEER will return 1 set with comments.
   b. Revise and/or amended as required and submit the requisite number of copies to the ENGINEER 15 days before Pre-commissioning of the systems.
4. Incorporate changes that occur during startup and submit as part of the final manuals.
5. Provide comprehensive information on all systems and components to enable operation, service, maintenance, and repair.
6. Organize the Operation and Maintenance Manuals for each process in the following manner:
   a. Section A-Description of operation.
   b. Section B- Screen shots.
   c. Section C- Report samples.
   d. Section D- Trending/recording operations.
   e. Section E- Software information with disks.
   f. Section F- Operational Manual.
   g. Section G- Spare Parts List.
7. Training Submittals:
   a. Develop and submit for review a General Training Plan. Include complete descriptions of all planned training classes, a preliminary training schedule, a list of all proposed instructors along with resumes, examples of proposed training manuals, and a description of any special training tools to be used (simulators, self-paced modules, personal computer-based training, etc.).
   b. The ENGINEER will review the General Training Plan. Special emphasis will be placed on review of the qualifications of the proposed instructors and the timing of the individual courses to maximize their effectiveness. If, in the opinion of the ENGINEER, the proposed instructors are not sufficiently qualified to conduct the specified training courses, or lack experience, where required, on the specific configuration of the system provide more qualified instructors.
   c. Training Course Plan submittals:
      1) For each training course or other training activity, submit a detailed, complete outline and agenda for each lesson.

2) Describe any student pre-requisites for the course or training activity.

3) Provide an updated schedule for all sessions of the course, including dates, times, durations, and locations.

4) Submit training materials.

d. Incorporate all submittal review comments into the course.

e. Do not conduct training courses before review and acceptance of the Course Plan submittal for the course.

D. Responsibilities

1. The Programming Contractor, shall be responsible to the OWNER for the implementation of the software and programmed systems.

2. Instrumentation & Control System Contractor (ICSC) Responsibilities:

a. The Programming Contractor shall assume full responsibility to perform all engineering to select, furnish, install, test, calibrate, and place into operation all software for PLC's and SCADA P.C.'s.

b. The Programming Contractor shall be responsible for coordination with OWNER to provide a complete, integrated and functional software system.

c. As a minimum, the Programming Contractor shall perform the following work:

1) Prepare software submittals.

2) Design, develop, and implement controls, screens, reporting, recording, etc.

3) Prepare the test plan, the training plan, and the spare parts submittals.

4) Procure all software.

5) Perform tests on PLC and SCADA software.

6) Participate in system pre-commissioning.

7) Participate in the performance tests.

8) Prepare Technical Manuals.

9) Conduct training classes.

3. Owner's Responsibilities:

a. Assist the Programming Contractor in coordinating and integrating the system controls.

b. The Programming Contractor shall not be responsible for providing or testing any hardware.

4. The Programming Contractor and the Instrumentation & Control System Contractor will be one and the same for this contract.

E. Programmer Qualifications:

1. The Qualification requirements specified in these paragraphs apply to the portions of the Process Control and Instrumentation System Work to be provided by the Programming Contractor.

2. The Programming Contractor shall meet the following minimum qualifications:
    a. The Programming Contractor shall have completed at least five (5) successfully completed projects for a pumping system of similar scope and complexity in which the Programming Contractor used components the same as those intended for use on this project, performed system programming, documentation, including software configuration and documentation, field testing, calibration and start-up, operator instruction and maintenance training.
    b. The Programming Contractor company shall be actively involved in the instrumentation, PLC based control systems, and SCADA systems business for a minimum of ten years and has adequate facilities, organization structure, manpower and technical and managerial expertise to properly perform the WORK under and in conformance with these Specifications.

1.6 SEQUENCING

A. General:
1. Testing requirements are specified in Division 27.
2. Work restrictions and other scheduling requirements are specified in the General specifications.

B. Pre-submittal Conferences:
1. Before producing any submittals, schedule a pre-submittal Conference for the purposes of reviewing the entire project, equipment, control philosophy, schedules, and submittal requirements.

C. Training:
1. Complete all training before the pre-commissioning phase of the project may start.
2. Schedule the training sessions a minimum of 15 days prior to the start date of the courses.
3. Submit training manuals to the ENGINEER a minimum of 10 days before starting the training session.
4. Within 10 days after the completion of each session, submit the following:
    a. A list of all OWNER personnel that attended the session.
    b. A copy of the training materials utilized during the lesson with all notes, diagrams, and comments.

D. Performance Testing:
1. Complete Pre-commissioning test a minimum of 5 days before the Performance Test.
2. Conduct a 90-day Performance Test.

1.7 WARRANTY

A. Warrant the Software and Programming in accordance with the General Conditions:

1. Provide additional warranty as specified in the individual Division 17 Specifications.

1.8 SYSTEM STARTUP

A. Replace or modify software, and materials that do not achieve design requirements after installation in order to attain compliance with the design requirements:

1. Following replacement or modification, retest the system and perform additional testing to place the complete system in satisfactory operation and obtain compliance acceptance from the ENGINEER.

1.9 MAINTENANCE

A. Before Substantial Completion, perform all maintenance activities required by any sections of the Specifications including any calibrations, final adjustments, component replacements or other routine service required before placing equipment or systems in service.

PART 2 - PRODUCTS

PART 3 - EXECUTION

3.1 DEMONSTRATION AND TRAINING

A. Training:

1. General:

a. Provide system maintenance and operator training courses for all the instrumentation and control systems furnished.

b. Conduct all training at the Project Site unless another location is approved by the ENGINEER and OWNER.

1) Include instruction on the use of all maintenance equipment and special tools provided under the contract.

c. Tailor training classes to the specific needs of the class participants:

1) The specific categories and number of personnel in each category are identified below.

2) Furnish training courses that are a combination of classroom and hands-on training:

3) Present the minimum number of sessions, specified in Table 1, for each course in order to satisfy class size restrictions and limitations scheduling OWNER staff.

4) Furnish additional sessions if required to accommodate the total number of personnel identified for each course.

5) Schedule individual training classes with the OWNER at least 3 weeks before the start of the class.

6) Schedule all training classes Monday - Friday between 7:30 AM and 3:30 PM.

7) Each individual daily training session, travel time excluded:

   a) Minimum duration of 4 hours.

   b) Maximum duration of 7 hours.

   c) Breaks scheduled at least every 90 minutes and 1 hour for lunch.

8) Complete training for maintenance personnel 90-days before Performance Testing.

9) Complete operator training classes before startup of the SCADA system, or any part of it:

10) Refer to Paragraph 1.09 of this Section.

11) Schedule follow-up training classes after SCADA startup on a schedule determined by the OWNER.

   a) Furnish highly qualified training instructors for technical training with demonstrated expertise in not only control system functionality but also professional training techniques:

   b) Provide completion reports in accordance with Paragraph 1.09 of this Section.

2. Training Manuals and Materials:

   a. Furnish training manuals and other materials for training courses.

   b. Manuals are to be professionally written to present the course material in a format that is easy to comprehend.

   c. The manuals are to serve as teaching aids during presentation of the training classes.

   d. Manuals are to serve as reference material after the training has been completed.

Table 1

Course Title	Minimum Course Length (days per session)	Personnel (Estimated Number of Students)	Minimum Number of Sessions
SCADA, HMI, PLC Software	1	5	1

3. Training Course Requirements:

   a. Software Training:

1) Furnish training on software and on related systems, including operation alarms, control, recording, reporting, etc.

2) Furnish training on features, operation, troubleshooting, and maintenance.

b. HMI Training:

1) Provide the following:

a) Overview of firmware, including starting, stopping, and PLC interface.

b) Troubleshooting.

c. Follow-up Training:

1) Provide on-site follow-up training class beginning after startup of the SCADA system. The intent for these classes is to provide the OWNER's personnel the opportunity for a review and "refresher" of the training topics and material after they have had some experience using the system.

2) Mutually schedule and develop the content of these classes with the OWNER no later than 1 month before the beginning of the first session:

a) Schedule at the OWNER's discretion on non-consecutive days spaced out over the start-up and warranty period.

END OF SECTION

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SECTION 16412
DISCONNECT SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

A. Includes But Not Limited To

1. Furnish and install disconnects as described in Contract Documents, except those provided integral with equipment.

B. Related Sections

1. Section “Electrical General Requirements”.
2. Section “Electrical Identification”.
3. Section “Fuses”.

1.2 SUBMITTALS

A. Submit product literature including manufacturer part number, model number, material, size, ratings, and specifications.

B. Refer to Section 16 05 00 for submittal requirements.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Manufacturer

1. 1. Same MANUFACTURER as Panels.

B. Disconnect Switches:

1. Heavy duty quick-make, quick-break type, fused, unless indicated otherwise. Provide a control switch for VFD fed motors which will disengage the VFD prior to opening the switch.
2. Provide interlock to prevent opening of door when switch is in ON position.
3. Provide means to lock switch in OFF position with padlock.
4. Disconnects for motor circuits shall be horsepower rated.
5. Where indicated on Drawings for small motors, disconnects shall be manual starter with thermal overload relay.
   a. Device shall have one pole per ungrounded conductor of motor.
   b. Provide overload relay to match motor full load amps.

c. Equip with lockout device.

6. Enclosures:

   a. Interior Dry locations - NEMA Type 12, or as indicated or required.

   b. Exterior, Damp, or Wet Locations - NEMA Type 4X Stainless steel, or as indicated or required.

7. Fuses:

   a. Fuse fused disconnects with dual-element time delay fuses and equip with rejection type fuse holders.

   b. Fuses on shall be from single manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Label disconnects to indicate equipment served, such as Condensing Unit CU-1. Use 1/16 inch (1.6 mm) thick laminated plastic composition material with contrasting color core. Engraved letter shall be 1/4 (6 mm) inch high. Attach labels with screws.

END OF SECTION

SECTION 16413
COPPER HORIZONTAL CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Scope of work

1. This section includes minimum requirements for product design, quality, and performance, including preparation and installation of telecommunications balanced unshielded twisted pair (UTP) cabling.

2. Balanced category 6 UTP horizontal cable is deployed from the telecommunications room (TR) to each workstation outlet. Category 6 cable is also used for backbone cabling. Riser cable is permitted for use in non-plenum areas. Plenum rated cable is required everywhere else. Terminated horizontal cables define the permanent link. Transmission testing is required for each cabled link. It is the responsibility of the cable installer to follow recognized installation practices. Compliance with codes and standards is required to achieve specified performance and network reliability.

3. This section includes specific requirements for the following:

a) Cable - category 6 balanced UTP, 550 mhz.

1.2 QUALITY ASSURANCE

A. Category 6 cables shall be installed according to recognized category 6 installation practices, and applicable codes and standards.

B. Installed category 6 cable shall be manufactured by an ISO 9001 certified facility.

C. Installed category 6 cable shall be free from defects in material or workmanship from the manufacturer, and shall be of the quality indicated.

D. Specified cable is based on acceptable manufacturers listed in the construction documents.

E. All methods of construction that are not specified in the contract documents shall be subject to control and approval by the owner or owner’s representative.

F. Installed cable shall be lot-traceable by lot number and date of manufacture printed on the outer cable jacket.

G. All critical internal manufacturing operations for category 6 cable shall have documented in-process inspection and testing according to ISO 9001.

H. Where “approved equal” is stated, any substitute product shall be equivalent to all requirements specified, and is subject to approval.

I. Materials and work specified in this document shall comply with, and are not limited to the applicable requirements of standards, codes, and publications listed below:

1. ANSI/TIA/EIA-568-b.1, commercial building telecommunications cabling standard (and all published addenda), part 1: general requirements, 2001.

2. ANSI/TIA/EIA-568-b.2, commercial building telecommunications cabling standard (and all published addenda), part 2: balanced twisted pair cabling components, 2001.

3. ANSI/TIA/EIA-568-b.2-1, commercial building telecommunications cabling standard, part 2: balanced twisted pair cabling components, addendum 1: transmission performance specifications for 4-pair 100 ohm category 6 cabling, 2002.
4. TIA/TSB-155 (current draft), telecommunications system bulletin: characterizing existing category 6 cabling for 10 gb/s Ethernet operation over 55 meters channel length.
5. ANSI/ICEA-S-90-661, category 6 individually unshielded twisted-pair indoor cables, with of without an overall shield, for use in communications wiring systems technical requirements, 2004.
6. IEEE 802.3af, data terminal equipment (DTE) power over media dependent interface (MDI), 2003 (superseded by IEEE 802.3-2005).
7. IEEE 802.3, information technology – telecommunications and information exchange between systems – local and metropolitan area networks – specific requirements part 3: carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications, 2005.
8. IEEE 802.3an (current draft), specification for 10 gb/s (10 gigabit Ethernet) operation over category 6 or higher 4-pair balanced twisted pair cabling.
9. ANSI/TIA/EIA-569-b, commercial building standard for telecommunications pathways and spaces, 2003.
10. ANSI/TIA/EIA-606-a, administration standard for commercial telecommunications infrastructure, 2002.
11. ANSI j-std-607-a, commercial building grounding and bonding requirements for telecommunications, 2002.
12. ISO/IEC 11801, information technology – generic cabling for customer premises, 2002.
13. ISO/IEC 18010, information technology – pathways and spaces for customer premises cabling, 2005.
14. ISO/IEC 14763-1, information technology – implementation and operation of customer premises cabling – part 1: administration, 2004.
15. BS EN 50173-1, information technology – generic cabling systems – part 1: general requirements, 2002.
16. BS EN 50174-1, information technology – cabling installation – part 1: specification and quality assurance, 2001
17. National fire protection association, inc., NFPA 70: national electric code (NEC), 2005.
    a. NEC article 250: grounding and bonding
    b. NEC article 800: communications circuits
18. CSA c22.1-06, Canadian electric code (CEC), 2006
19. Underwriters laboratory, inc., UL1863: standard for safety – communications circuit accessories, 4th ed, 2004.

20. Telecommunications distribution methods manual, 10th ed., building industry consulting services international (BICSI), 2003.

21. Information transport systems installation manual, 4th ed., building industry consulting services international (BICSI), 2004.

1.3 SUBMITTALS

A. Product data sheet

B. Manufacturer's instructions

C. Product catalog literature

D. Product drawing

E. Third party verification certificates (upon request)

1.4 REFERENCES

A. Master format, 2004 ed., the construction specifications institute, 2004.

B. The project resource manual, CSI manual of practice, 5th ed., the construction specifications institute, 2005.

1.5 WARRANTY

A. Product is warranted free of defects in material or workmanship.

B. Product is warranted to perform the intended function within design limits.

C. Installed category 6 cable may be granted a full link or channel warranty by Hubbell premise wiring under the conditions stated below.

1. Construction is performed by an installer that is certified by the Hubbell mission critical® warranty program or equal of amp or Leviton.

2. Contractors performing the certified installation are properly registered in the Hubbell mission critical® warranty program.

3. The link or channel components are supplied entirely by Hubbell or equal of amp or Leviton (including patch cords for channel).

4. Cable used in the installation is qualified and recognized by the manufacturer.

5. Links or channels in the installation are properly documented and tested with a "pass" result. (see "field quality control – testing" in part 3 of this document for testing details).

6. Required test results and project documentation is submitted to the manufacturer by the registered contractor.

PART 2 - PRODUCTS

2.1 CABLE - CATEGORY 6 BALANCED UTP CABLE, 550 MHZ RISER

A. Design requirements

1. Cable construction shall be four twisted pairs of 23 AWG insulated solid conductors, with a ripcord, surrounded by a tight outer jacket.

2. Cable shall be manufactured with an “x”-shaped pair-divider along the center to maintain separation of individual pairs.

3. Conductor diameters shall be 0.0224” ± .0003” solid copper.

4. Conductor insulation diameter shall be 0.040” ± .0005” flame retardant polyolefin.

5. Twist lay of each pair shall vary in a manner to optimize noise immunity and minimize crosstalk.

6. Outer jacket diameter shall be 0.230” ± .008” PVC, with a nominal wall thickness of 0.015”.

7. Ripcord shall be directly underneath the outer jacket.

8. Cable shall be marked: “Hubbell premise wiring nextspeed category 6 550 mhz – riser -- 4 pr 23 AWG C(UL)US CMR – (UL) verified to TIA/EIA-568-b.2-1 -- z/yy(xxxx) – nnnn”.

   a) Frequency of marking shall be every 2.0 ft.

   b) ‘z’ represents the month of manufacture.

   c) ’yy’ indicates the year of manufacture.

   d) ’xxxx’ indicates the job number.

   e) ’nnnn’ indicates the sequential footage markers.

9. UL, ETL, or CSA agency certification or verification markings shall be marked on the cable jacket according to the certifying agency’s requirements.

10. Color coding of the pairs shall be as follows:

    a) Pair 1: white/blue; blue

    b) Pair 2: white/orange; orange

    c) Pair 3: white/green; green

    d) Pair 4: white/brown; brown

11. Cable shall be supplied in 1000 ft spools or 1000 ft reelex boxes.

B. Performance requirements

1. All transmission performance parameters shall be independently verified by a UL or ETL third party testing organization.

2. Cable shall exceed category 6 transmission requirements specified in ANSI/TIA/EIA-568-b.2-1, and shall be tested through 550 mhz.

3. Cable shall exceed the requirements of TIA/TSB-155: 10 gb/s Ethernet operation over 55 meters channel length.

4. Worst-case cable performance shall be +8.0 db headroom over current TIA/EIA and ISO standards limits for next and PSNEXT loss, and ELFEXT and PSELFEXT loss.

5. Insertion loss shall be 3.0% lower than standard Hubbell category 6 plenum and riser cables described in section 16761.

6. Worst case electrical performance characteristics shall be as follows:

   a) Characteristic impedance:100 +15(1.0-100 MHz) 100 +20(101-250 MHz)

   b) Maximum conductor resistance:9.38 Ohm /100 meters @ 20°c

   c) Maximum resistance unbalance: 3%

   d) Maximum mutual capacitance: 5.6 nF/100 meters @ 1 kHz

   e) Maximum capacitance unbalance: 330 pF/100 meters

   f) Maximum delay skew: 25 ns/100 meters

7. The manufacturer shall provide category 6 component compliance certificates from third party testing organization upon request.

8. Cable shall be UL and C(UL) listed.

9. Cable shall exceed IEEE 802.3 DTE power specification to 4 times the rated current limits with no degradation of performance or materials.

10. Cable shall be third party verified, error free gigabit Ethernet performance to IEEE 802.3 standard.

11. Cable shall meet or exceed the 4-connector channel performance requirements of category 6, per the ANSI/TIA/EIA-568-b.2-1 standard.

12. The 4-connector channel test configuration shall utilize category 6 jacks and patch panels, with category 6 patch cords, from the same manufacturer, with qualified category 6 cable.

13. The 4-connector channel performance margins in the table below shall be guaranteed, provided the configuration satisfies requirement no. 12 above.

Electrical parameter (1 - 250mhz)	Guaranteed margins to category 6 / class e channel specifications
Insertion loss	3 %
NEXT	4 dB
PSNEXT	5 dB
ELFEXT	4 dB
PSELFEXT	5 dB
Return loss	2 dB

PART 3 - EXECUTION

3.1 PREPARATION

A. Horizontal pathways (conduit, cable tray, raceway, etc.) Shall be fully deployed from the TR or TE to each wall plate location according to applicable codes and standards.

B. Metallic horizontal cable pathways shall be bonded to an approved ground according to ANSI-J-STD-607-a.

3.2 INSTALLATION

A. Using approved methods, pull cable into conduits, or place into raceway or cable tray as specified. Do not exceed 25 lb pull force per cable. Use appropriate lubricants as required to reduce pulling friction.

B. All exposed wiring shall be installed in surface raceway.

C. All wiring above ceilings or below access floors shall be installed in cable tray or open-top cable hangers.

D. Cable slack and service loops shall be stored properly above the ceiling or under the access floor. A "figure-eight" service loop is recommended for category 6 cabling to reduce EMI coupling.

E. Pathway fill ratio in conduit, tray, raceway, etc. Shall not exceed 40% of pathway cross-sectional area.

F. Installed cable bend radius shall be greater than 4x cable diameter. Avoid kinking or twisting the cable during installation.

G. Do not over-tighten cable ties, and do not use staples or clamps to anchor cables. Velcro straps are recommended.

H. Recommended spacing of cable supports above the ceiling shall be 48".

I. Maintain the following clearances from EMI sources:

1. Power cable in parallel: 12 in.
2. Power cable intersections: 6 in.
3. Florescent lights: 12 in.
4. Transformers and electrical service enclosures: 36 in.

J. Communications cabling that must cross power cables or conduit shall cross at a 90-degree angle, and shall not make physical contact.

K. Length of each horizontal cable run from the TR to the wall outlet shall not exceed 90 meters.

L. Leave sufficient slack for 90 degree sweeps at all vertical drops.

M. Do not install cable in wet areas, or in proximity to hot water pipes or boilers.

N. Cable ends for termination shall be clean and free from crush marks, cuts, or kinks left from pulling operations.

O. Installed cable jackets shall have no abrasions with exposed conductor insulation or bare copper ‘shiners”. The installer is responsible to replace damaged cables.

P. Horizontal cables extending from mounted jacks or panels shall maintain a minimum bend radius of at least 4 times the cable diameter.

Q. Firestop all cable penetrations through fire-rated barriers per local codes.

R. For termination of panels in the tr, refer to section 16760: “communications termination blocks and patch panels”.

S. For termination of jacks in the wall outlet, refer to section 16761: “communications faceplates and connectors”.

3.3 FIELD QUALITY CONTROL – TESTING

A. Cables are tested in the fully terminated condition, as part of the installed horizontal cabling system. Jacks in the wall outlet, and panels in the tr are to be terminated complete, with faceplates assembled complete and properly mounted.

B. For termination of panels in the TR, refer to section “communications termination blocks and patch panels”.

C. For termination of jacks in the wall outlet, refer to section “communications faceplates and connectors”.

D. Each link or channel in the horizontal cabling system shall be identified and tested individually, using an industry standard level iii tester with correct settings.

A. Test cables in the horizontal channel or link for the parameters listed below.

1. Wire map / Continuity
2. Length
3. Insertion Loss
4. NEXT
5. PSNEXT
6. ELFEXT
7. PSELFEXT
8. Delay and Delay Skew
9. Return Loss

E. A “pass” indication shall be obtained for each channel or link, using a level iii tester. The installer is responsible to correct any test failures.

F. Completed test reports shall be submitted per contract requirements of “field test reporting”.

G. See “warranty” in part 1 for provisions of the Hubbell link or channel full coverage warranty.

END OF SECTION

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SECTION 16416
BRANCH CIRCUIT PANELBOARD

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Lighting and Appliance Panelboard - Furnish and install lighting and appliance panelboard(s) as specified herein and where shown on the associated schedules drawings.

1.2 REFERENCES

The panelboard(s) and circuit breaker(s) referenced herein are designed and manufactured according to the latest revision of the following specifications.

A. NEMA PB 1 – Panelboards

B. NEMA PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.

C. NEMA AB 1 - Molded Case Circuit Breakers

D. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)

E. UL 50 - Enclosures for Electrical Equipment

F. UL 67 – Panelboards

G. UL 98 - Enclosed and Dead-front Switches

H. UL 489 - Molded-Case Circuit Breakers and Circuit Breaker Enclosures

I. CSA Standard C22.2 No. 29-M1989 - Panelboards and Enclosed Panelboards

J. CSA Standard C22.2 No. 5-M91 - Molded Case Circuit Breakers

K. Federal Specification W-P-115C - Type I Class 1

L. Federal Specification W-C-375B/Gen - Circuit Breakers, Molded Case, Branch Circuit And Service.

M. NFPA 70 - National Electrical Code (NEC)

N. ASTM - American Society of Testing Materials

1.3 SUBMITTAL AND RECORD DOCUMENTATION

A. Approval documents shall include drawings. Drawings shall contain overall panelboard dimensions, interior mounting dimensions, and wiring gutter dimensions. The location of the main, branches, and solid neutral shall be clearly shown. In addition, the drawing shall illustrate one line diagrams with applicable voltage systems.

1.4 QUALIFICATIONS

A. Company specializing in manufacturing of panelboard products with a minimum of fifty (50) years documented experience.

B. Panelboards shall be manufactured in accordance with standards listed.

1.5 DELIVERY, STORAGE, AND HANDLING

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

B. Handle carefully to avoid damage to panelboard internal components, enclosure, and finish.

C. Store in a clean, dry environment. Maintain factory packaging and, if required, provide an additional heavy canvas or heavy plastic cover to protect enclosure(s) from dirt, water, construction debris, and traffic.

1.6 OPERATIONS AND MAINTENANCE MATERIALS

A. Manufacturer shall provide installation instructions and NEMA Standards Publication PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.

1.7 WARRANTY

A. Manufacturer shall warrant specified equipment free from defects in materials and workmanship for the lesser of one (1) year from the date of installation or eighteen (18) months from the date of purchase.

1.8 RELATED WORK

A. Section “Transient Voltage Surge Suppression” or “Surge Protection Devices”.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Square D Company Type NF - Class 1670.

B. Cutler Hammer / Eaton.

C. General Electric.

2.2 LIGHTING AND APPLIANCE PANELBOARD TYPE

A. Fabrication:

1. Interior

a. Continuous current ratings, as indicated on Drawings, not to exceed 600 amperes maximum for main breaker panelboards and not to exceed 800 amperes for main lug panelboards.

b. Minimum Short Circuit Rating: as indicated on the Drawings.

c. Provide one (1) continuous bus bar per phase. Each bus bar shall have sequentially phased branch circuit connectors limited to bolt-on branch circuit breakers. The bussing shall be fully rated. Panelboard bus current ratings shall be determined by heat-rise tests conducted in accordance with UL 67. Bussing rated 100-400 amperes shall be plated copper. Bussing rated for 600 and 800 amperes shall be plated copper as standard construction. Bus bar plating shall run the entire length of the bus bar. Panelboards shall be suitable for use as Service Equipment when application requirements comply with UL 67 and NEC Articles 230-F and -G.

d. All current-carrying parts shall be insulated from ground and phase-to-phase by high dielectric strength thermoplastic.

e. A solidly bonded copper equipment ground bar shall be provided.

f. Split solid neutral shall be plated and located in the mains compartment up to 250 amperes so all incoming neutral cable may be of the same length.

g. Interior trim shall be of dead-front construction to shield user from energized parts. Dead-front trim shall have pre-formed twistouts covering unused mounting space.

h. Nameplates shall contain system information and catalog number or factory order number. Interior wiring diagram, neutral wiring diagram, UL Listed label and short circuit current rating shall be displayed on the interior or in a booklet format.

i. Interiors shall be field convertible for top or bottom incoming feed. Main circuit breakers in 125A interiors shall be vertically mounted. Main circuit breakers over 125A shall be vertically mounted. Sub-feed circuit breakers shall be vertically mounted. Main lug interiors up to 400 amperes shall be field convertible to main breaker. Interior leveling provisions shall be provided for flush mounted applications.

j. Interior phase bus shall be pre-drilled to accommodate field installable options. (i.e., Sub-Feed Lugs, Sub-Feed Breakers, Thru-Feed Lugs)

k. Interiors shall accept 125 ampere breakers in group mounted branch construction.

2. Main Circuit Breaker

a. Shall be bolt-on type circuit breakers.

b. Main circuit breakers shall have an over center, trip-free, toggle mechanism which will provide quick-make, quick-break contact action. Circuit breakers shall have a permanent trip unit with thermal and magnetic trip elements in each pole. Each thermal element shall be true RMS sensing and be factory calibrated to operate in a 40° C ambient environment. Thermal elements shall be ambient compensating above 40° C.

c. Two and three pole circuit breakers shall have common tripping of all poles. Circuit breakers frame sizes above 100 amperes shall have a single magnetic trip adjustment located on the front of the breaker that allows the user to simultaneously select the desired trip level of all poles. Circuit breakers shall have a push-to-trip button for maintenance and testing purposes.

d. Circuit breaker handle and faceplate shall indicate rated ampacity.

Standard construction circuit breakers shall be UL Listed for reverse connection without restrictive line or load markings.

e. Circuit breaker escutcheon shall have international I/O markings, in addition to standard ON/OFF markings. Circuit breaker handle accessories shall provide provisions for locking handle in the ON or OFF position.

f. Lugs shall be UL Listed to accept solid or stranded copper conductors only. Lugs shall be suitable for 90° C rated wire, sized according to the 75° C temperature rating per NEC Table 310-16. Lug body shall be bolted in place; snap-in designs are not acceptable.

g. The circuit breakers shall be UL Listed for use with the following accessories: Shunt Trip, Under Voltage Trip, Ground Fault Shunt Trip, Auxiliary Switch, Alarm Switch, Mechanical Lug Kits, and Compression Lug Kits.

3. Branch Circuit Breakers

a. Circuit Breakers shall match the brand of the panel. Circuit breakers shall be UL Listed with amperage ratings, interrupting ratings, and number of poles as indicated on the panelboard schedules drawings.

b. Molded case branch circuit breakers shall have bolt-on type bus connectors.

c. Circuit breakers shall have an over center toggle mechanism which will provide quick-make, quick-break contact action. Circuit breakers shall have thermal and magnetic trip elements in each pole. Two- and three-pole circuit breakers shall have common tripping of all poles.

d. There shall be two forms of visible trip indication. The circuit breaker handle shall reside in a position between ON and OFF. In addition, there shall be a red VISI-TRIP® indicator appearing in the clear window of the circuit breaker housing.

e. The exposed faceplates of all branch circuit breakers shall be flush with one another.

f. Lugs shall be UL Listed to accept solid or stranded copper conductors only. Lugs shall be suitable for 90° C rated wire, sized according to the 75° C temperature rating per NEC Table 310-16.

g. Breakers shall be UL Listed for use with the following factory installed accessories: Shunt Trip, Auxiliary Switch, and Alarm Switch.

h. Breaker shall be UL Listed with the following ratings: (15-125A) Heating, Air Conditioning, and Refrigeration (HACR), (15-30A) High Intensity Discharge (HID), and (15-20A) Switch Duty (SWD)

4. Enclosures

a. Type 1 Boxes

1) Boxes shall be galvanized steel constructed in accordance with

UL 50 requirements. Galvannealed steel will not be acceptable.

2) Boxes shall have removable end walls with knockouts located on one end. Boxes shall have welded interior mounting studs. Interior mounting brackets are not required.

3) Box width shall not exceed 26” wide.

b. Type 1 Fronts

1) Front shall meet strength and rigidity requirements per UL 50 standards. Shall have ANSI 49 gray enamel electrodeposited over cleaned phosphatized steel.

2) Fronts shall be hinged 1-piece with door. Mounting shall be surface as indicated on associated drawings. <u>All</u> covers shall be hinged cover type.

3) Panelboards rated 250 amperes and below shall have MONO-FLAT fronts with concealed door hinges and trim screws. Front shall not be removable with the door locked. Panelboards rated above 250 amperes shall have vented fronts with concealed door hinges. Doors on front shall have rounded corners; edges shall be free of burrs.

4) Front shall have flat latch type lock with catch and spring loaded stainless steel door pull. All lock assemblies shall be keyed alike. One (1) key shall be provided with each lock. A clear plastic directory card holder shall be mounted on the inside of door.

c. Type 4, and 12

1) Enclosures shall be constructed in accordance with UL 50 requirements. Enclosures shall be painted with ANSI 49 gray enamel electrodeposited over cleaned phosphatized steel.

2) All doors shall be hinged cover type. All doors shall be gasketed and equipped with a tumbler type vault lock and two (2) additional quarter turn fasteners on enclosures 59 inches or more in height. All lock assemblies shall be keyed alike. One (1) key shall be provided with each lock. A clear plastic directory card holder shall be mounted on the inside of door.

3) Maximum enclosure dimensions shall not exceed 21” wide and 9.5” deep.

5. Surge Protective Device

a. Integral Surge Suppressor shall be provided for <u>each</u> branch circuit panelboard.

PART 3 - EXECUTION

3.1 <u>INSTALLATION</u>

A. Install panelboards in accordance with manufacturer's written instructions, NEMA PB

1.1 and NEC standards.

3.2 FIELD QUALITY CONTROL

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

B. Measure steady state load currents at each panelboard feeder; rearrange circuits in the panelboard to balance the phase loads within 20% of each other. Maintain proper phasing for multi-wire branch circuits.

C. Check tightness of bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written specifications.

3.3 INSTALLATION OF PANELS

A. Installation: Unless otherwise indicated on the drawings, install wall panels with the top of the trim 6'-0" above the finished floor. Panels located in equipment rooms and wire closets shall be surface mounted. Floor mounted panels shall be provided with a 4" concrete housekeeping pad. Floor mounted panels shall be anchored to floor at all four corners and to wall or structural member at top for seismic restraint.

B. Directories: Mount a typewritten directory behind glass or plastic on the inside of each panel door. On the directory, show the circuit number and complete description of all outlets with specific locations on each circuit. In addition, provide a typewritten label inside door showing source of power to panel both as to feeder switch, panel designation and location within buildings.

END OF SECTION

SECTION 16419
PATCH CORDS, STATION CORDS & CROSS CONNECT WIRE

PART 1 - GENERAL

1.1 SUMMARY

A. Scope of work

1. This section includes minimum requirements for product design, quality, and performance, including preparation and installation of telecommunications balanced unshielded twisted pair (UTP) cabling.
2. Balanced category 6 UTP horizontal cable is deployed from the telecommunications room (TR) to each workstation outlet. Category 6 cable is also used for backbone cabling. Riser cable is permitted for use in non-plenum areas. Plenum rated cable is required everywhere else. Terminated horizontal cables define the permanent link. Transmission testing is required for each cabled link. It is the responsibility of the cable installer to follow recognized installation practices. Compliance with codes and standards is required to achieve specified performance and network reliability.
3. This section includes specific requirements for the following:
   a) Cable - category 6 balanced UTP, 550 mhz.

1.2 QUALITY ASSURANCE

A. Category 6 cables shall be installed according to recognized category 6 installation practices, and applicable codes and standards.

B. Installed category 6 cable shall be manufactured by an ISO 9001 certified facility.

C. Installed category 6 cable shall be free from defects in material or workmanship from the manufacturer, and shall be of the quality indicated.

D. Specified cable is based on acceptable manufacturers listed in the construction documents.

E. All methods of construction that are not specified in the contract documents shall be subject to control and approval by the owner or owner's representative.

F. Installed cable shall be lot-traceable by lot number and date of manufacture printed on the outer cable jacket.

G. All critical internal manufacturing operations for category 6 cable shall have documented in-process inspection and testing according to ISO 9001.

H. Where "approved equal" is stated, any substitute product shall be equivalent to all requirements specified, and is subject to approval.

I. Materials and work specified in this document shall comply with, and are not limited to the applicable requirements of standards, codes, and publications listed below:

1. ANSI/TIA/EIA-568-b.1, commercial building telecommunications cabling standard (and all published addenda), part 1: general requirements, 2001.
2. ANSI/TIA/EIA-568-b.2, commercial building telecommunications cabling standard (and all published addenda), part 2: balanced twisted pair cabling components, 2001.

3. ANSI/TIA/EIA-568-b.2-1, commercial building telecommunications cabling standard, part 2: balanced twisted pair cabling components, addendum 1: transmission performance specifications for 4-pair 100 ohm category 6 cabling, 2002.
4. TIA/TSB-155 (current draft), telecommunications system bulletin: characterizing existing category 6 cabling for 10 gb/s Ethernet operation over 55 meters channel length.
5. ANSI/ICEA-S-90-661, category 6 individually unshielded twisted-pair indoor cables, with of without an overall shield, for use in communications wiring systems technical requirements, 2004.
6. IEEE 802.3af, data terminal equipment (DTE) power over media dependent interface (MDI), 2003 (superseded by IEEE 802.3-2005).
7. IEEE 802.3, information technology – telecommunications and information exchange between systems – local and metropolitan area networks – specific requirements part 3: carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications, 2005.
8. IEEE 802.3an (current draft), specification for 10 gb/s (10 gigabit Ethernet) operation over category 6 or higher 4-pair balanced twisted pair cabling.
9. ANSI/TIA/EIA-569-b, commercial building standard for telecommunications pathways and spaces, 2003.
10. ANSI/TIA/EIA-606-a, administration standard for commercial telecommunications infrastructure, 2002.
11. ANSI j-std-607-a, commercial building grounding and bonding requirements for telecommunications, 2002.
12. ISO/IEC 11801, information technology – generic cabling for customer premises, 2002.
13. ISO/IEC 18010, information technology – pathways and spaces for customer premises cabling, 2005.
14. ISO/IEC 14763-1, information technology – implementation and operation of customer premises cabling – part 1: administration, 2004.
15. BS EN 50173-1, information technology – generic cabling systems – part 1: general requirements, 2002.
16. BS EN 50174-1, information technology – cabling installation – part 1: specification and quality assurance, 2001
17. National fire protection association, inc., NFPA 70: national electric code (NEC), 2005.
    a. NEC article 250: grounding and bonding
    b. NEC article 800: communications circuits
18. CSA c22.1-06, Canadian electric code (CEC), 2006
19. Underwriters laboratory, inc., UL1863: standard for safety – communications circuit accessories, 4th ed, 2004.
20. Telecommunications distribution methods manual, 10th ed., building industry consulting services international (BICSI), 2003.

21. Information transport systems installation manual, 4th ed., building industry consulting services international (BICSI), 2004.

1.3 SUBMITTALS

A. Product data sheet

B. Manufacturer's instructions

C. Product catalog literature

D. Product drawing

E. Third party verification certificates (upon request)

1.4 REFERENCES

A. Master format, 2004 ed., the construction specifications institute, 2004.

B. The project resource manual, CSI manual of practice, 5th ed., the construction specifications institute, 2005.

1.5 WARRANTY

A. Product is warranted free of defects in material or workmanship.

B. Product is warranted to perform the intended function within design limits.

C. Installed category 6 cable may be granted a full link or channel warranty by Hubbell premise wiring under the conditions stated below.

1. Construction is performed by an installer that is certified by the Hubbell mission critical® warranty program or equal of AMP (TE Connectivity by CommScope Holding Company) or Leviton.

2. Contractors performing the certified installation are properly registered in the Hubbell mission critical® warranty program.

3. The link or channel components are supplied entirely by Hubbell or equal of AMP (TE Connectivity by CommScope Holding Company) or Leviton (including patch cords for channel).

4. Cable used in the installation is qualified and recognized by the manufacturer.

5. Links or channels in the installation are properly documented and tested with a "pass" result. (see "field quality control – testing" in part 3 of this document for testing details).

6. Required test results and project documentation is submitted to the manufacturer by the registered contractor.

PART 2 – PRODUCTS

2.1 CATEGORY 6 PATCH CORDS

A. Design requirements

1. Category 6 patch cords shall be constructed with a smoke-colored polycarbonate plug having vertically staggered, trifurcated contacts, each having 50 micro-inches of gold plating.

2. Plug dimensions and function shall comply with FCC 47, part 68.5.

3. Patch cords shall have a snag-less feature, integral to the strain relief boot on each end. Strain relief boot shall be molded PVC, and color matched to the cable jacket.
4. Patch cords shall be constructed with category 6 patch cable, with 24 AWG 7/32 tinned copper stranded conductors, each insulated with polyethylene, and overall jacket with UL flame-retardant PVC.
5. Patch cords shall be manufactured using a T568b wiring format, and shall function suitably for either T568a or T568b wiring schemes.
6. Patch cords shall be available in the following colors: black, blue, gray, yellow, orange, red, green, white, and purple. Custom lengths and colors shall be available with a delivery lead-time quotation.
7. Standard patch cord lengths shall range from 3 ft. to 20 ft.
8. Category 6 patch cords shall be backward compatible with existing category 3, 5, and 5e cabling systems for fit, form, and function.

B. Performance requirements

1. All transmission performance parameters shall be independently verified by a UL or ETL third party testing organization.
2. Category 6 patch cords shall be channel performance balanced with Hubbell category 6 jacks, patch panels, and punch-down blocks.
3. Category 6 patch cords shall meet or exceed category 6 component transmission requirements for connecting hardware, as specified in ANSI/TIA/EIA-568-b.2-1 standard.
4. The manufacturer shall provide category 6 component compliance certificates from third party testing organization upon request.
5. Patch cords shall be CUL and UL listed 1863.
6. Patch cords shall exceed IEEE 802.3 DTE power specification to 4 times the rated current limits with no degradation of performance or materials.
7. Patch cords shall be third party verified, error-free gigabit Ethernet performance to IEEE 802.3 standard.
8. Jacks shall exceed 4 gb/s data transmission capacity within the bandwidth of 1 – 250 mhz when configured in a 4-connector channel.
9. Category 6 patch cords shall meet or exceed the 4-connector channel transmission performance requirements of category 6, per ANSI/TIA/EIA-568-b.2-1 standard.
10. The 4-connector channel test configuration shall utilize category 6 patch panels, blocks, and jacks, with category 6 patch cords, all from the same manufacturer, with qualified category 6 cable.
11. The 4-connector channel performance margins in the table below shall be guaranteed, provided the configuration satisfies requirement no. 9 above.

12. Category 6 patch cords shall meet the current draft 10 gb/s transmission performance requirements of TSB-155, provided the configuration satisfies requirement no. 9 above.

Electrical parameter (1 - 250mhz)	Guaranteed margins to category 6 / class e channel specifications
Insertion loss	3 %
NEXT	4 db
PSNEXT	5 db
ELFEXT	4 db
PSELFEXT	5 db
Return loss	2 db

PART 3 - EXECUTION

3.1 PREPARATION

A. Horizontal and backbone cabling of the proper category shall be fully deployed throughout the building according to applicable codes and standards.

B. Telecommunications outlet locations, patch panels in each TR, and patch panels in the ER shall be installed and terminated complete per manufacturer's instructions, and applicable codes and standards.

C. Where applicable, any consolidation point or MUTOA locations shall be permanently mounted and terminated complete.

D. Faceplates at each outlet shall be assembled complete and properly mounted.

E. Metallic horizontal cable pathways shall be bonded to an approved ground according to ANSI-J-STD-607-a.

3.2 INSTALLATION

A. Remove patch cords from bags and apply channel or port identification labels per specification. Patch cord lengths should match the distance between connection points, with enough slack for cable management and bend radius control.

B. For cross-connect panels in the ER or TR, place the patch cords properly into the installed front cable organizer. Plug each end into the respective panel and equipment ports. Push the plug into the receptacle until the latch clicks into position. Installed patch cords should be neat, with no kinks, tangles, or tight bends.

C. To connect workstation equipment to the outlet, route the patch cord behind furniture and plug into the network port. Patch cords should not interfere with the operator space or electrical cords. Note: workstation cords are normally installed after placement of office furniture.

3.3 FIELD QUALITY CONTROL – TESTING

A. Note: if permanent link tests are complete, and channel testing is not required in the contract documents, then channel testing after patch cord installation is not required. Proceed with step ‘b’ below only if channel testing is required in the contract documents.

B. For channel testing, each channel in the horizontal and backbone cabling system shall be identified and tested individually, using an industry standard level iii tester with correct settings.

C. Each channel, including patch cord on each end, shall be tested for the parameters listed below.

1. Wire map / Continuity
2. Length
3. Insertion Loss
4. NEXT
5. PSNEXT
6. ELFEXT
7. PSELFEXT
8. Delay and Delay Skew
9. Return Loss

D. A “pass” indication shall be obtained for each channel using a level iii tester.

E. Completed test reports shall be submitted per contract requirements of “field test reporting”.

F. See “warranty” in part 1 for provisions of the Hubbell channel full coverage warranty.

END OF SECTION

SECTION 16423
FIBER CABLE AND EQUIPMENT

PART 1 GENERAL

1.1 SCOPE

A. Section Includes:

1. Requirements for fiber optic cable and related hardware including:
   a. Fiber Optic Cable.
   b. Fiber Splices and Terminations
   c. Fiber Patch Panels.
   d. Related accessories.
2. Requirements for Video and control using Fiber and Coax cable.

B. Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the CONTRACTOR and its Sub-Contractors to review all sections to ensure a complete and coordinated project.

C. Furnish all a complete fiber optic network as indicated in the plans, as shown on the cable or system block diagrams; and as specified herein.

1.2 REFERENCES

A. Fiber optic cable and termination equipment supplied under this contract shall be designed, manufactured, and tested in accordance with the latest version of the following standards:

1. Electronic Industry Association (EIA) 455B "Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components".

FOTP – 1	Cable Flexing for Fiber Optic Interconnecting Devices
FOTP – 2	Impact Test Measurements for Fiber Optic Devices
FOTP – 3	Procedure to Measure Temperature Cycling Effects on Optical Fibers, Optical Cable, and Other Passive Fiber Optic Components
FOTP – 4	Fiber Optic Connector/Component Temperature Life
FOTP – 5	Humidity Test Procedure for Fiber Optic Connecting Devices
FOTP – 11	Vibration Test Procedure for Fiber Optic Connecting Devices and Cables.
FOTP – 17	Maintenance Aging of Fiber Optic Connectors and Terminated Cable Assemblies
FOTP – 18	Acceleration Testing of Fiber Optic Components and Assemblies
FOTP – 21	Mating Durability for Fiber Optic Interconnecting Devices

FOTP – 25	Repeated Impact testing of Fiber Optic Cables and Cable Assemblies
FOTP – 26	Crush Resistance of Fiber Optic Interconnecting Devices
FOTP – 28	Method of Measuring Dynamic Tensile Strength of Optical Fibers
FOTP – 31	Fiber Tensile Proof Test Method
FOTP – 32	Fiber Optic Circuit Discontinuities
FOTP – 33	Fiber Optic Cable Tensile Loading and Bending Test
FOTP – 34	Interconnecting Device Insertion Loss Test
FOTP – 35	Fiber Optic Component Dust (Fine Sand) Test
FOTP – 36	Twist Test for Fiber Optic Connecting Devices
FOTP – 37	Low or High Temperature Bend Test for Fiber Optic Cable
FOTP – 41	Compressive Loading Resistance of Fiber Optic Cables
FOTP – 59	Measurements of Fiber Point Defects Using an OTDR
FOTP – 61	Measurement of Fiber or Cable Attenuation Using an OTDR
FOTP – 78	Spectral Attenuation Cutback Measurement for Single mode Optical Fibers
FOTP – 80	Cutoff Wavelength of Un-cabled Single mode Fiber by Transmitted Power
FOTP – 81	Compound Flow (Drip) Test for Filled Fiber Optic Cable
FOTP – 82	Fluid Penetration Test for Fluid-Blocked Fiber Optic Cable
FOTP – 85	Fiber Optic Cable Twist Test
FOTP – 86	Fiber Optic Cable Jacket Shrinkage
FOTP – 88	Fiber Optic Cable Bend Test
FOTP – 89	Fiber Optic Cable Jacket Elongation and Tensile Strength
FOTP – 91	Fiber Optic Cable Twist-Bend Test
FOTP – 98	Fiber Optic Cable External Freezing Test
FOTP – 169	Chromatic Dispersion Measurement of Single mode Optical Fibers by the Phase-Shift Method
FOTP – 170	Cable Cutoff Wavelength of Single mode Fiber by Transmitted Power
FOTP – 178	Measurements of Strip Force Required for Mechanically Removing Coatings from Optical Fibers

2. TIA/EIA Standards:
    a. TIA/EIA-568-B (Series), Commercial Building Telecommunications Standards.
    b. TIA/EIA-569 (Series), “Commercial Building Standard for Telecommunications Pathways and Spaces.”
3. Bellcore Standards:

a. Bellcore GR-20, "Generic Requirements for P\Optical Fiber and Optical Fiber Cables.

b. Bellcore GR-409, "Generic Requirements for Intrabuilding Fiber."

4. ICEA Standards:

   a. S-83-596 "Fiber Optic Premises Distribution Cables."

   b. S-87-640, "Fiber Optic Outside Plant Communications Cable."

   c. S-104-696, "Fiber Optic Premises Distribution Cables.

1.3 SUBMITTALS

A. Product Data:

   1. Complete manufacturer's brochures that identify instrument construction, accuracy, ranges, materials, and options. Mark up to clearly show options and components to be provided, and cross out any options or components that will not be provided.

   2. Completed data sheets, including catalog number and source for determining catalog number.

   3. Manufacturer's installation instruction.

   4. Produce data submitted under this section shall include:

      a. Provide manufacturer's data on testing equipment used on this project.

      b. Provide manufacturer's specifications and data sheets for all fiber types.

      c. Provide manufacturer's specifications and data sheets for all connectors, bulkheads, splicing kits, breakout devices and appurtenances used connecting and terminating the fiber spans.

B. Shop drawings showing interconnection cabling diagrams for the complete system showing every fiber in each cable.

C. Catalog data on all testing devices proposed for use plus certifications of accuracy, calibration, and traceability to standards of the national Institute for Standards and Testing.

D. Drawings indicating the locations of all pull boxes, include pull box identifiers and lengths.

E. Cable pulling calculations for all conduit runs. Indicate on the submittal any additional pull boxes that are required, including pull box identifiers and a written description of the location.

F. Test Reports:

   1. The results of all tests specified under this section shall be submitted to the ENGINEER. Fiber tests shall include:

      a. Factory test results on fiber optic cable.

      b. Field test on delivered fiber optic cable before installation.

      c. Field test on installed fiber optic cable before termination.

d. Field tests on installed fiber optic cable after all splices and terminations are completed.

G. Operating Manuals:

1. After completion of testing, the test reports, instruction manuals, and manufacturer's information shall be compiled into the "operating manuals".

H. Record Drawings:

1. Electrical drawings, network diagrams, and fiber cable block diagrams shall be updated at the end of construction and submitted as record drawings.

1.4 QUALITY ASSURANCE

A. Furnish materials suitable for the purpose for which they are used, considering strength, ductility, and durability.

B. All cable and appurtenances have been manufactured within one year of installation.

C. All optical fibers shall be proof tested by the fiber manufacturer at a minimum load of 50 kpsi.

D. All optical fibers shall be 100 percent attenuation tested. The attenuation of each fiber shall be provided with each cable reel.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Fiber optic cable and termination equipment shall be delivered complete, in manufacturer's original, unopened protective packaging. Packing materials shall be such as to prevent damage to the materials during transportation and handling.

B. Maintain protective coverings until ready for installation.

C. The completed cable shall be packaged for shipment on non-returnable wooden reels.

D. Top and bottom ends of the cable shall be available for testing on reels.

E. Each cable reel shall have a weatherproof label, which shows the actual length of cable on the reel.

F. Both ends of the cable shall be sealed to prevent the ingress of moisture.

G. The cable manufacturer shall provide installation procedures and technical support concerning the items contained in this specification.

1.6 PROJECT/SITE CONDITIONS

A. Fiber optic installation work may need to occur in parallel with heavy construction work. The CONTRACTOR shall take steps, as necessary, to protect the fiber system from physical damage and the encroachment of dust.

B. Refer to Section “project environmental conditions”.

1.7 WARRANTY

A. All cable and equipment shall carry a one year parts and labor warranty.

PART 2 - PRODUCTS

2.1 CABLE ASSEMBLIES

A. General Fiber Cable Requirements:

1. Cable construction shall be suitable for the environment where it is scheduled to be installed.
2. Each fiber shall be distinguishable from others by means of color coding according to EIA/TIA-598, “Color Coding of Fiber Optic Cables.”
3. Buffer tubes containing fibers shall also be color coded with distinct and recognizable colors according to EIA/TIA-598, “Color Coding of Fiber Optic Cables.”
4. In buffer tubes containing multiple fibers, the colors shall be stable during temperature cycling and not subject to fading or smearing onto each other or into the gel filling materials. Colors shall not cause fibers to stick together.
5. Buffer tubes shall be a single layer nylon construction of similar mechanical performance.
6. Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed.
7. The central anti-buckling member shall consist of a glass reinforced plastic rod. The purpose of the central member is to prevent buckling of the cable.
8. Binders shall be applied with sufficient tension to secure the buffer tubes to the central member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking (or rendered so by the flooding compound), and dielectric with low shrinkage.
9. The cable shall contain at least one ripcord under the sheath for each sheath removal.
10. Tensile strength shall be provided by high tensile strength aramid yards.
11. The high tensile strength Aarmid yards, Keviar, and/or fiberglass shall be helically stranded evenly around the cable core. There shall be no metallic elements whatsoever in non-armored cable so that the cable is entirely an insulator.
12. The jacket or sheath shall be free of holes, splits, and blisters.

13. The jacket or sheath shall be marked with the manufacturer's name, the words "Optical Cable," year of manufacture, and sequential meter marks. The markings shall be repeated every one-meter. The actual length of the cable shall be within 1 percent of the length marking. The marking shall be in a contrasting color to the cable jacket. The height of the marking shall be approximately 2.5 mm.
14. The shipping, storage, and operating temperature range of the cable shall be -40 degrees C to +70 degrees C.
15. General Performance Characteristics:
    a. The rated tensile load of the cables shall be 2670 N (600 lbf). Fibers within the cable shall experience a fiber strain of no greater than 60 percent of the fiber proof test level.
    b. The non-armored fiber optic cables shall withstand a compressive load of 220 N/cm applied uniformly over the length of the cable. The armored fiber optic cables shall withstand a compressive load of 440N/cm applied uniformly over the length of the cable. The average increase in attenuation for the fibers shall be < 0.10 dB at 1550 nm for a cable subjected to this load. The cable shall not exhibit any measurable increase in attenuation after load removal. Testing shall be in accordance with FOTP-41, "Compressive Loading Resistance of Fiber Optic Cable", except that the load shall be applied at the rate of 3 mm to 20 mm per minute and maintained for 10 minutes.
    c. The cable shall be capable of withstanding 25 cycles of mechanical flexing at a rate of 30-+ 1 cycles/minute. The average increase in attenuation for the fibers shall be < 0.10 dB at 1550nm at the completion of the test. For armored cables, any visible cracks causing separation of the armor and propagating more than 5 mm shall constitute failure. Outer cable jacket cracking or splitting observed under 10 X magnification, shall constitute failure.
16. Packaging:
    a. Fiber cable assemblies shall be placed on reels such that both cable ends are available for testing. Fable ends shall be sealed against the entrance of moisture.
    b. Cable reel markings shall include the following:
        1) Manufacturer
        2) Date of Manufacture
        3) Shipping date
        4) Cable Identification
        5) Cable configuration/Fiber Count
        6) Cable Length
        7) Gross Weight
        8) Cable test data
        9) Handling instructions
        10) Direction to unreel

17. Acceptable fiber cable assembly manufacturers:
    a. ~~ADC/KRONE~~ TE Connectivity by CommScope Holding Company Group
    b. Berk-Tek
    c. Corning Cable Systems
    d. Pirelli
    e. Or Approved equal

B. Outside Plant Cable:
   1. General:
      a. Application: Install cable outside of structures. Install in conduit unless otherwise indicated.
   2. Cable Construction:
      a. Cable Type: Outdoor only. Fully preventing the entrance of water.
      b. Fiber count: 24
      c. Fiber Type: Single mode
      d. Buffer Tube: Loose Tube
      e. Armoring: None
      f. Strength Member: Central nonmetallic strength member with a coefficient of thermal expansion similar to the fibers.
      g. Design and Test Criteria: ICEA S-87-640.
   3. Where require each buffer tube shall be filled with a non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogenous gel. The gel shall be free from dirt and foreign matter. The gel shall be readily removable with conventional non-toxic solvents.
   4. The cable core interstices shall be filled with a water-blocking compound that is a non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogenous gel. The gel shall be free from dirt and foreign matter. The gel shall be readily removable with conventional non-toxic solvents.
   5. Armored cables shall have an inner sheath of low or medium density polyethylene. The minimum nominal jacket thickness of the inner sheath shall be 0.5 mm. The inner jacket shall be applied directly over the tensile strength members and flooding compound. The armor will be a corrugated stainless steel tape, plastic-coated on both sides for corrosion resistance, and applied with an overlapping seam with the corrugations in register. All armor splices shall be recoated with plastic to further enhance the armor's corrosion resistance. The outer jacket shall be applied over the corrugated steel tape armor. The outer jacket shall be a low or medium density polyethylene with a minimum nominal jacket thickness of 1.25 mm. The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus.

6. The fiber optic cable shall withstand water penetration when tested with a one meter static head or equivalent continuous pressure applied at one end of a one meter length of filled cable for one hour. No water shall leak through the open cable end. Testing shall be done in accordance with FOTP-82, “Fluid Penetration Test for Filled Fiber Optic Cable.”

7. The cable shall exhibit no flow (drip or leak) at 80 degrees C. The weight of any compound that drips from the sample shall be less than 0.05 grams (0.002 ounce). A representative sample of cable shall be tested in accordance with FOTP-81, “Compound Flow (Drip) Test for Filled Fiber Optic Cable.” The test sample shall be prepared in accordance with method A.

8. Acceptable fiber cable assembly manufacturers:

   a. ~~ADC/KRONE~~ TE Connectivity by CommScope Holding Company Loose Tube Outside Plant Cable.

   b. Berk-Tek.

   c. Corning Cable Systems.

   d. Pirelli.

   e. Or approved equal.

C. Indoor Cable:

1. General:

   a. Application: Install in conduit in the interior of structures where exposure to moisture can be minimized.

2. Cable Construction:

   1) Cable Type: Indoor – Flame Retardant, Low Smoke, Zerio Halogen.

   2) Fiber Count: 24.

   3) Fiber Type: Singlemode.

   4) Buffer Tube: Loose Tube.

   5) Armoring: None.

   6) Strength Member: Central nonmetallic strength member with a coefficient of thermal expansion similar to the fibers.

   7) Approvals and Listings: NEC OFN approved to general purpose indoor applications.

   8) Design and Test Criteria: S-83-596.

   b. All fiber in the cable shall conform to a proof test of 100 kpsi. Each optical fiber shall conform to Bellcore GR-409 strip force testing. There shall be no gaps between the coating material and the buffer material visible under a 50-power microscope.

c. The outer jacket material shall be a linear low-density polyethylene. The color of the polyethylene jacket material shall be black in accordance with ASTM D 1248. The indoor cable jacket shall meet all requirements of the NEC for use in all indoor areas without being enclosed in conduit. The indoor jacket shall be flame retardant riser rated conforming to UL 1666. Jacket shall be printed with all necessary UL marks and manufacturer identification. Additionally, sequential printing of footage shall occur in 2-foot increments. A ripcord shall be incorporated under the cable jacket.

3. Acceptable fiber cable assembly manufacturers:

   a. Corning/Altos non-conductive plenum rated.

   b. ~~ADC/KRONE~~ TE Connectivity by CommScope Holding Company Group.

   c. Berk-Tek.

   d. Pirelli.

   e. Or approved equal.

D. Singlemode Fibers:

1. All fibers in the cable must be usable fibers and meet required specifications.

2. All optical fibers shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical, and environmental requirements of this specification.

3. Each optical fiber shall consist of a doped silica core surrounded by a concentric silica cladding.

4. Single Mode Fiber Specifications.

   a. All fiber optic cables between facilities shall be single-mode.

   b. Optical Specifications

      1) Fibers shall operate at wavelengths between 1310 nm and 1625 nm.
      2) Attenuation: ≤ 0.03 dB/km at 1310 nm and ≤0.02 dB/km at 1550 nm.

   c. Dimensional Specifications

      1) Fiber Curl ≥ 4.0 radius of curvature
      2) Cladding diameter 125.0 ± 0.7 µm
      3) Core-Clad Concentricity ≤ 0.5 µm
      4) Non-Circularity ≤ 0.7%
      5) Coating diameter 245 ± 5 µm
      6) Coating-Cladding Concentricity < 12 µm

   d. Environmental Specifications

      1) Operating Temperature Range: -60ºC to +85ºC

   e. Mechanical Specifications
      1) The entire fiber length is subjected to a tensile stress ≥ 100 kpsi

5. Acceptable fiber cable manufacturers:
    a. ~~ADC/KRONE~~ TE Connectivity by CommScope Holding Company Group
    b. Berk-Tek
    c. Corning Cable Systems

2.2 <u>ACCESSORIES</u>

A. Fiber Patch Panels – LIU – Light Interface Unit.
    1. All optical fibers shall be provided with strain relief and terminated at a fiber patch panel. All patch panel terminations shall be SC type. Final connections between the patch panel and the fiber optic network equipment shall be made via fiber optic patch cords.
    2. All fibers, active and dark, shall be terminated at the patch panels.
    3. Interconnect and patch panel housings shall provide space for excess fiber and provide strain relief for the fiber cable.
    4. Fiber cables shall be installed such that the outer sheath of the cable is carried into the interconnect enclosure or patch panels before breaking out buffer tubes.
    5. Wall Mounted Interconnect:
        a. Application: Use for the termination of a single cable outside of cabinets, in small enclosures or as indicated on the plans.
        b. Wall mounted fiber interconnects shall be provided as complete units including the housing, the connector panels and the fiber connectors.
        c. Wall mounted fiber interconnects shall provide physical protection for both the incoming cable and the outgoing patch cords.
        d. Accessories:
            1) Door lock
            2) Blanks for unused connector panels.
        e. Manufacturers:
            1) The part number shall match those existing in the treatment plant, or approved by OWNER.
    6. Rack Mounted Fiber Patch Panel – LIU – Light Interface Unit.
        a. Application: Use for the termination of one or more fiber cables terminating on open EIA racks and in enclosures with EIA racks.
        b. Fiber patch panels shall be provided as complete units including the housing, the connector panels, mounting hardware and the fiber connectors.
        c. patch panels shall be provided with hardware for standard 19-inch or 23-inch rack mounting, as required.
        d. Capacity: As shown in the Contract Documents.

e. Manufacturers:

1) The part number shall match those existing in the treatment plant, or approved by OWNER.

B. Patch Cords:

1. General:

a. Connector types shall be selected by the CONTRACTOR to match supplied equipment and the patch panel terminations.

b. Two spare patch cords (or one duplex patch cord) of each type used shall be provided at each patch panel.

c. Cables shall be factory assembled and optically tested.

2. Manufacturer:

a. Multimode:

1) MM patch cords shall be CommScope 62.5 SC/SC duplex patch cords

2) MM patch cords shall be CommScope 62.5 SC/ST duplex patch cords.

3) MM patch cords shall be CommScope 62.5 ST/ST duplex patch cords.

b. Single Mode:

1) SM patch cords shall be CommScope Single Mode SC/SC duplex patch cords.

2) SM patch cords shall be CommScope Single Mode SC/ST duplex patch cords.

3) SM patch cords shall be CommScope Single Mode ST/ST duplex patch cords.

c. Or approved equal.

C. Fiber Connectors:

1. Fiber optic cable connectors shall be the heat-cured epoxy and polish kit type. Kit shall contain all necessary items to perform the connections and polishing including: connectors, hardware, tools, epoxy, oven, and other supplies. Terminations shall be SC, with composite hardware, over-cured epoxy, and composite or ceramic ferrules. Crimp on or UV-curable connectors are not acceptable.

2. Manufacturer:

a. Multimode: Connectors shall be CommScope epoxy/polish MM connectors.

b. Single Mode: Connectors shall be CommScope epoxy/polish SM connectors.

D. Splices:

1. All splice locations shall be approved by the ENGINEER prior to install of the fiber cables.

2. Field splices shall be placed in a splice tray and these splice tray(s) shall then be placed in a splice enclosure. Splice enclosure shall be waterproof. Splice enclosure shall be Tyco/Raychem FOSC style splice enclosure, or equal.

3. The individual fibers shall be looped a minimum of one full turn within the splice tray to avoid macro/micro bending.

4. All splices shall be protected with a thermal shrink sleeve.

5. All FIBER OPTIC CABLE splicing shall be of the fusion type and meet the following requirements:

   a. Joins multimode or single mode fibers

   b. Establishes a permanent fusion splice.

   c. Waterproof.

   d. Reenterable, rearrangable and reusable.

   e. Splice loss < 0.10 dB.

   f. Protected by a Splice Enclosure

   g. Outdoor: The fiber splice enclosure shall seal, bond, anchor and protect fiber optic cable splices. The splice enclosure shall be a stand-alone unit that does not require an outer enclosure. An outdoor splice enclosure shall provide for a maximum of six (6) cable entries in a butt-end configuration. The splice enclosure shall be used in aerial, underground, and direct buried applications.

   h. Indoor: The fiber splice enclosure shall anchor and protect fiber optic cable splices. The splice enclosure shall be a stand-alone unit that does not require an outer enclosure. The enclosure shall provide for the minimum number of splices at the location plus additional capacity for reconfigurations.

   i. If any splice has a loss greater than 0.10 dB it shall be re-spliced at the CONTRACTOR's expense.

6. All fiber optic connectors shall be fabricated using oven heat cured epoxy method. Ambient cured or UV cured epoxy methods are not acceptable. Each connector shall be hand polished to a maximum insertion loss when mated of 0.75 dB.

7. Active and spare fiber optic cables shall be provided and installed with all required connectors and appurtenances for all data highway links.

E. Terminations:

1. All fiber cables shall terminate at a fiber patch panel.

2. Outdoor cables shall be terminated using a breakout kit that seals the cable and provides physical protection for the fiber strands.

3. Indoor cables shall be terminated using breakout kits with field installed terminators.

4. All splices performed in termination cabinets and enclosures shall be installed in splice trays.

5. All cable terminations shall be permanently labeled. Labels shall be comparable in print quality and durability to labels produced by a Bradymaker printer using pressure sensitive polyester labels. Patch panels shall be labeled according with the Division 16 requirements for the labeling of cables.

F. Provide inner duct in fiber optic conduits.

G. Innerduct

1. All fiber cabling shall be run in innerduct. The innerduct shall be sized by the CONTRACTOR.

H. Buffer Tube Fiber Fan-Out Kits

1. Buffer Tube Fan-Out Kits shall be supplied for the termination of each buffer tube at end of the installed fiber cables.
2. Fan-Out Kits shall be color coded to match the color scheme of the fiber cabling.
3. Fan-Out Kits shall have a minimum length of 25 inches.
4. Fan-Out Kits shall be Corning FAN-BT25-12 or approved equal.

I. Fiber Optic Connectors

1. Fiber Optic Connectors shall not require the use of epoxy of polish.
2. Fiber Optic Connectors shall be of ceramic construction for 50 µm fiber at bandwidths of 4700 MHz and shall have a loss ≤ 0.5 dB.
3. Fiber Optic Connectors shall utilize the SC type connector.
4. Fiber Optic Connectors shall be anaerobic polished connectors or approved equal.

J. Fiber Patch Cords

1. The fiber patch cord shall be duplex and consist of buffered, graded-index fiber with a 50 µm core and a 125 µm cladding for multimode. The fiber cladding shall be covered by aramid yarn and a jacket of flame-retardant PVC.
2. The fiber patch cord shall be rated for 10 Gigabit Ethernet.

2.3 <u>FIBER TERMINATION TOOLKIT</u>

A. Provide a Fiber Termination Toolkit to the Government following the completion of the SCS installation. The Toolkit shall be compatible with the Connectors used for terminating the fiber cabling and shall have the necessary components to make at least 100 additional terminations.

B. The Toolkit shall contain hard copies of installation instructions as well as an installation video that illustrates the step-by-step procedure for installing the Fiber Optic Connectors.

C. The Toolkit shall have test equipment that is capable of determining if a Connector was installed correctly.

D. The Toolkit must be an approved installation system of the manufacturer of the fiber optic cabling and connectors.

E. The Toolkit shall be the Corning anaerobic polished type or equal.

F. CTC's shall be installed with at least 36" clear working space in front and behind cabinet.

G. CTC's shall have a slide-out shelf suitable for a laptop computer to be placed on it for system configuration/programming. The shelf shall be vented. The shelf shall be CPI 12335-719 or approved equal.

2.4 <u>SOURCE QUALITY CONTROL</u>

A. Factory Test:

1. While on the shipping reel, after cabling but before shipment, 100 percent of all fibers shall be tested for attenuation. Copies of the results shall be:
    a. Maintained on file.
    b. Attached to the cable reel in a waterproof pouch.
    c. Submitted to the CONTRACTOR and the ENGINEER before the delivery of the cable to the job site.
2. Conduct the flex test in accordance with FOTP-104, “Fiber Optic Cable Cyclic Flexing Test,” except that the sheave diameter shall be a maximum diameter of 20X the cable OD. Test the cable in accordance with Test Conditions I and III of the FOTP.
3. The cable shall withstand 25 impact cycles. The average increase in attenuation for the fibers shall be <0.20 dB at 1550nm. The cable jacket shall not exhibit evidence of cracking or splitting. Conduct the test in accordance with FOTP-25, “Impact Testing of Fiber Optic Cables and Cable Assemblies.”
4. The cable shall withstand a tensile load of 2700 N (600 pounds) without exhibiting an average increase in attenuation of greater than 0.10 dB. This test shall be conducted in accordance with FOTP-33, “Fiber Optic Cables and Cable Assemblies”.
5. The cable shall withstand a simulated lightning strike with a peak value of the current pulse > 105kA. The test current used will be damped oscillatory with a maximum time-to-peak value of 15 us (which corresponds to a minimum frequency of 16.7 kHz) and a maximum frequency of 30 kHz. The time to half-value of the waveform envelope will be from 40 to 70 us. Conduct the test in accordance with the proposed FOTP-181, “Lightning Damage Susceptibility Test for Optic Cables with Metallic Components.” In addition to the analysis criterion set forth in FOTP-181, the integrity of the buffer tubes (or analogous loose tube, i.e. core tube) and strength members must be intact after removal of the cable specimens for the test box.

PART 3 EXECUTION

3.1 EXAMINATION

A. The CONTRACTOR shall be responsible for verifying the condition of the conduit system before installation of the fiber optic cable or inner duct. A test mandrel shall be passed through all fiber optic conduit spans. The test mandrel shall be run in both directions.

B. The CONTRACTOR shall examine all materials and equipment before installation and verify they are free from physical damage and defects.

3.2 INSTALLATION

A. All Fiber optic system components shall be installed per the recommendations of the manufacturer.

B. Fiber optic cable shall be installed in continuous lengths without intermediate splices, except where approved by the ENGINEER in writing. The cable installation personnel shall be experienced with specific knowledge of the cable manufacturer’s recommended procedures, and as a minimum shall conduct their work to conform to the following.

1. The fiber optic cable’s strength elements shall be properly attached to a 600 lb breakaway swivel using Kellums pulling grips, minimum, 18-inches long.
2. Cable tensile limits and tension monitoring devices shall not exceed cable pull tension and bend limits.
3. All conduits shall be constantly lubricated during the pulling procedures.
4. Each pull box shall contain extra fiber optic cable for pull box slack.

C. The CONTRACTOR shall conform with the cable manufacturer’s specifications, practices, and the following requirements.

1. When power equipment is used to install fiber optic cables, low speeds shall be used so that a rate of 30 meters per minute is not exceeded. The tensile and bending limitation for fiber optic cables shall not be exceeded under any circumstances. Large diameter wheels, pulling sheaves, and cable guides shall be used to maintain the specified bending radius. Tension monitoring shall be accomplished using commercial dynamometers or load-cell instruments. A nonfreezing type of swivel shall be inserted between the pulling line and cable pulling grip to prevent twisting under strain. The swivel shall be equipped with shear or tension pins with a breaking strength of 600 pounds.
2. No cable shall be pulled without a breakaway swivel.
3. All conduits shall have a lubricant applied at each conduit ingress and egress location and during the pull operation. Lubricant shall be poured or pumped into the end of the conduit at the feed location at a nominal application rate of 3 gallons per 1000 feet of cable. If the conduit is open at intermediate locations, then the appropriate proportion of lubricant shall be applied at each opening. As the cable is being pulled, lubricant shall be poured into the conduit at the feed location and at each intermediate location. Workmen shall be stationed at each intermediate location as required. After cable pulling, all excess lubricant that has collected shall be removed and the surrounding area cleaned.
4. Fiber optic cable shall be installed using a hydraulic capstan or winch equipped with a recording running line dynamometer graph which measures and records pulling tensions. The pulling equipment shall have “slip-load” capability to allow the winch to maintain a constant pulling force without taking up the winch line. The pulling equipment shall also be equipped with a hydraulic bypass that shall be set so that a maximum tension of 600 pounds is not exceeded. All equipment shall be designed to prevent a preset pulling tension from being exceeded. The pulling tension setpoint shall be determined by the fiber optic cable manufacturer. If during the pulling operation excessive tension is detected, all operations shall cease and the ENGINEER shall be notified.

5. The cable reel shall be positioned at the feed point in alignment with the raceway and in such a position that the cable can be passed from the top of the reel in a long, smooth bend into the raceway system. The use of a cable feeder is required.

6. The CONTRACTOR shall supply all bull wheels, blocks, split wheels, cable feeders, and necessary equipment required to provide a clean and safe operation. The cable shall not be allowed to travel over any wheel or block that has a radius less than the minimum radius allowed by the cable manufacturer.

7. The use of snatch blocks and rollers to guide the cable into the conduit at the feed point shall be minimized. The cable shall be fed slack by hand into the feed point and raceway without the use of rollers wherever possible. The cable reel shall be tended at all times and shall be turned by hand to provide the required cable slack. Under no circumstances shall the cable tension be allowed to turn the cable reel. A rim roller, with a wheel radius greater than the minimum cable bending radius shall be placed at the manhole or vault opening to prevent the cable from dragging on the manhole rim or steps.

8. A thorough visual inspection for flaws, breaks, and abrasions in the cable sheath shall be made as the cable leaves the reel, and the pulling speed shall be slow enough to permit the inspection. Damage to the sheath or finish of the cable shall be sufficient cause for rejecting the cable. Cable damaged in any way during installation shall be replaced by and at the expense of the CONTRACTOR. All cable shall be available for inspection by the ENGINEER continuously during installation. ENGINEER shall be notified in writing 5 days in advance of any installation.

9. If the cable becomes damaged during installation, the CONTRACTOR shall stop their operations and notify the ENGINEER immediately. The ENGINEER will determine whether to replace the entire reel of cable or to install a termination panel to eliminate the damaged section.

10. All pulls shall be documented by a graph which is annotated with the following information:

    a. Reel number

    b. Pull point ID.

    c. Date and time.

    d. Explanations for abnormalities in readings or interruptions.

    e. Sign-off by CONTRACTOR or ENGINEER.

11. Under no conditions shall the fiber optic cable be left exposed or unattended.

D. After the cables are installed and spliced, they shall be racked and spare conduits sealed. A minimum of 20 feet of fiber optic cable shall be stored at each end of one splice. Racking shall conform to the following.

1. Cables shall be loosely secured in racked position with Ty-Raps or equal.

2. Imprinted plastic coated cloth identification/warning tags shall be securely attached to the cables in at least two locations in each hand hole. Tags shall be by Brady or Thomas & Betts.

3. All coiled cable shall be suitably protected to prevent damage to the cable and fibers. Racking shall include securing cables to brackets and racking hardware that extend from the sidewalls of the hand hole.

4. When all cables at each hand hole are securely racked, unused conduits and void areas around conduit containing cables shall be sealed using the Semco or equal material.

E. Armored fiber optic cables containing metallic members shall be grounded per the requirements of Article 770 of the National Electrical Code.

F. Other cables shall be listed as nonconductive fiber cable.

3.3 FIELD QUALITY CONTROL

A. General:

1. The CONTRACTOR shall conduct tests of the fiber optic system.

2. All test results shall meet or exceed manufacturer specifications. Any fiber that does not meet or exceed manufacturer specifications shall be replaced at the CONTRACTOR's expense. Tests are to be performed on each fiber of each cable, and to be tested for breaks, abnormalities, and overall attenuation characteristics.

3. Before conducting any tests, the CONTRACTOR shall provide the ENGINEER with detailed descriptions of test procedures for review and approval. Pre-installation tests and Post-installation tests to be witnessed and signed off by ENGINEER and GOVERNMENT.

4. The CONTRACTOR shall provide the ENGINEER with a copy of the manufacturers' test procedures and quality assurance procedures for information. If the ENGINEER determines that these procedures are not adequate, the ENGINEER may require that additional tests be conducted by the CONTRACTOR before installation. Additional testing ordered by the ENGINEER will be paid for by the CONTRACTOR.

5. Testing shall be performed at four separate stages: (1) the factory, (2) after delivery but before installation, (3) after delivery to the job site but prior to installation, and (4) after installation and as part of final system testing.

6. The CONTRACTOR shall provide documentation certifying that the fiber optic cable has passed each testing stage. Provide separate documentation for each testing stage result.

7. Attenuation tests shall be performed with an Optical Loss Test Set capable and calibrated to show anomalies of 0.1 dB as a minimum. Multimode fibers shall be tested at 850 nm and 1300 nm. Single mode fibers shall be tested at 1310 and 1550 nm.

8. OTDR tests performed on fiver cables less than 100 meters shall be performed with the aid of a launch cable. OTDR pulse width settings shall be adjusted to a maximum setting of 1/1000th of the cable length or 10 nanoseconds.

9. All tests required to ensure the satisfactory installation, adjustments, operation, and performance of all equipment and materials erected and installed under this specification, shall be performed by the CONTRACTOR.

10. The CONTRACTOR shall also furnish all test equipment, meters, instruments and miscellaneous equipment and perform all work required for the tests.

B. Test Reports:

1. The CONTRACTOR shall furnish the ENGINEER three copies of all test reports showing the results of all tests specified herein. Test forms shall clearly label the test type, the test location, test date, wavelength, index of refraction, cable identification, fiber type, fiber number, fiber color, and the result of the value of the tested parameter. All OTDR traces shall be supplied on printed hard-copy, and on 3-1/2 inch floppy disk media. Test reports shall state "PASS" or, 'NOT PASSED."

C. Site Test and Inspection:

1. Subsequent to the Post-Installation testing, the fiber network shall be placed into service and functional tested along with the control system and network components. Installed system tests are described in Section 40 10 00.

3.4 ADJUSTING

A. After completion of cable terminations, fiber cables shall be neatly dressed.

B. At the completion of construction, touch up the finish on all fiber patch panels and enclosures, as required.

3.5 CLEANING

A. After termination and before testing, all fiber optic connectors shall be cleaned. After cleaning, all un-terminated connectors shall be covered with a protective boot.

B. At the completion of construction, fiber enclosures shall be cleaned.

3.6 DEMONSTRATION

A. Testing shall be scheduled so that the ENGINEER or GOVERNMENT's representative witness the testing activities.

3.7 PROTECTION

A. All materials delivered to site shall be protected and stored in a suitable environment.

END OF SECTION

SECTION 16426
TERMINAL BLOCKS

PART 1 - GENERAL

1.1 SCOPE OF WORK:

A. This section covers terminal blocks for control and other wiring.

1.2 SUBMITTALS:

A. Products shall be submitted in accordance with Section 16 05 00, and elsewhere in the Contract Documents, prior to installation.

1.3 MANUFACTURERS:

A. Terminal blocks shall be Entrelec, Phoenix Contact, Weidmuller, or equal.

B. Surge protection blocks shall be MTL Surge Technologies, Series SD, or equal.

C. Power distribution blocks shall be Ilsco Corporation, or equal.

PART 2 - PRODUCTS

2.1 TERMINAL BLOCKS:

A. Terminal blocks shall mount on standard DIN rail, and be of the size required for conductors therein. A minimum of 25 percent spares shall be provided in each terminal box. No more than 2 conductors shall be allowed per termination. Jumper bar assemblies shall be installed for interconnecting terminal blocks, distributing power and signal commons. Terminal blocks shall be U.L. rated for 600 Volts, and 30 Amps, minimum.

B. Grounding terminal blocks shall be provided for instrumentation cable shields. The terminal blocks shall have distinctive 2-color bodies, and shall be mounted to the DIN rail with metal screw down type clamps, providing a positive ground connection. One grounding terminal block shall be installed for every 2 instrument cables terminated. Grounding terminal blocks shall be U.L. rated for 600 Volts, and 20 Amps, minimum.

C. Terminal blocks shall be available in a variety of colors, including red, green, blue, gray, black, yellow, and orange.

D. DIN mount fuse holders shall have blown fuse indicators for EC and AC circuits. Fuse holders shall be of the compression clamp type. Fuse holders shall be U.L. listed, and rated for 600 Volts. Fuse sizes shall not exceed the U.L. current rating for the fuse holders.

E. DIN rail shall be prepunched, zinc bichromate plated steel. Symmetrical DIN rail shall be 35 mmX7.5mm, minimum.

F. Terminal blocks for 4 to 20 milliamp signals shall have knife disconnect switches, and accessible test points for testing and measurement of current loop signals, without the need for removing wire terminations.

2.2 SURGE PROTECTION BLOCKS (SPB):

A. Analog inputs and outputs shall be terminated at surge protection blocks (SPB). He SPBs shall be designed for a working voltage of 32 volts, and shall be fused.

B. SPBs shall provide full hybrid line to line protection, and shall have a GDT rating of 10,000 A (8/20us pulse waveform).

C. SPBs shall be UL94 V-2 listed.

2.3 POWER DISTRIBUTION BLOCKS (PDB):

A. PDBs shall be Electro-tin plated and manufactured from high strength 6061-T6 aluminum alloy.

B. PDBs shall be UL Recognized rated 90º and CSA Certified.

C. PDBs shall provide flexibility in using the connector as an in line splice or to reduce conductor size.

D. PDBs shall be rated for 600 Volts and dual rated for Copper and Aluminum Conductor.

E. PDBs shall have the sizes and ratings per NEC.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Each terminal block and fuse holder shall be identified with the circuit number, or conductor number, corresponding to the identification appearing on the shop Drawings for the equipment, or system.

B. Terminal block and fuse holder markers shall be computer printed plastic-type, with permanent markings.

C. End clamps and end sections shall be installed on each terminal block and fuse holder assembly.

D. Terminal blocks for DC voltages shall be blue, and AC voltages shall be gray.

END OF SECTION

SECTION 16480
TESTING, CALIBRATION, AND COMMISSIONING

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes:
   1. Testing requirements that apply to all process control and instrumentation systems for the entire project.

B. Related Sections:
   1. The Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the CONTRACTOR and its Sub-Contractors to review all sections to ensure a complete and coordinated project.

1.02 REFERENCES

1.03 DEFINITIONS

1.04 (NOT USED)

1.05 SUBMITTALS

A. General:
   1. For each test described in Parts 2 and 3, herein, and described in other sections of Division 16, prepare and submit complete Test Plans, Test Procedures, Test Forms, Test Binders, and Test Reports, and other submittals, as specified below.
   2. Submit Manufacturer's Certifications and Manufacturer's Field Reports where required.
   3. Submit Test Plans, Procedures, Forms, and Binders for approval by the ENGINEER before scheduling or performing tests.
   4. Develop the PCIS system test submittals in consultation and cooperation with all applicable subcontractors.
   5. Additional Test Form and Test Procedure requirements are specified with individual test requirements.

B. Overall Test Plan:
   1. Develop and submit an overall testing plan for the PCIS. The Overall Test Plan to be reviewed and approved by the ENGINEER before detailed test plans, procedures, and forms will be reviewed.
   2. Describe the test phases, as they apply specifically to this project and each process system.
   3. Provide a preliminary testing schedule to show the sequence of tests and commissioning as they apply to each process system and each PLC.
   4. Provide a description of factory tests. Describe what equipment will be included, what testing equipment will be used, and the simulator that will be used.
   5. Provide examples of proposed forms and checklists.

C. Test Procedures:
1. Develop and submit detailed test procedures to show that the integrated SCADA system hardware and software is fully operational and in compliance with the requirements of the Contract Documents.
2. Provide a statement of test objectives for each test.
3. Prepare specific procedures for each process system.
4. Describe sequentially the steps to be followed in verifying the correct operation of each process system, including all features described in the loop descriptions, control strategies. Implied or generic test procedures are not acceptable.
5. Specify who will perform the tests, specifically what testing equipment will be used (including serial numbers and NIST-traceable calibration), how the testing equipment will be used.
6. Describe the expected role of the ENGINEER, as well as any requirements for assistance from OWNER's staff.
7. Provide the forms and checklists to be used.

D. Test Forms:
1. Provide test and calibration forms and checklists for each of the following:
   a. Calibration.
   b. Factory Demonstration Tests.
   c. Loop Validation Tests.
   d. Pre-commissioning Test.
   e. Performance Test.
2. Test forms shall include the detailed test procedures, or shall include clear references to separate pages containing the complete test procedure applicable to each form. If references to procedures are used, the complete procedure shall be included with each test binder.
3. Every page of each test form shall include project name, date, time, name of person conducting the test, signature of person conducting the test, and for witnessed tests, place for signature of person (ENGINEER and OWNER) witnessing the test.
4. Some sample test forms are included at the end of this Section. These test forms show the minimum required test form content. They are not complete, and have not been customized for this project. The CONTRACTOR to develop and submit test forms customized for the project and meeting all of the specified test and submittal requirements.

E. Testing Binders:
1. Sub-system to be tested, provide and submit a Test Binder containing all test procedures and individual test forms for the test. References to other documents for test procedures and requirements are not acceptable.
2. Fill out in advance headings and all other information known before the test.
3. Include applicable test plan information, as well as a list of all test prerequisites, test personnel, and equipment.
4. Include or list reference material and provide separately at the time of the test.
5. Record test results and verify that all test requirements and conditions have been met.

F. Factory Test Procedure additional minimal requirements:
1. Prepare and submit a factory test procedure which includes:

a. Control system testing block diagram.
b. Estimated test duration.
c. Details on the simulator construction, components, and operation.

G. Test Reports:
1. At the conclusion of each test, submit a complete Test Report, including all test results and certifications.
2. Include all completed test binders, forms, and checklists.
3. Submission, review, and acceptance of each Test Report is generally required before the start of the sub-system.

1.06 QUALITY ASSURANCE

A. Test Personnel:
1. Furnish qualified technical personnel to perform all calibration, testing, and verification. The test personnel are required to be familiar with this project and the equipment, software, and systems before being assigned to the test program.

1.07 DELIVERY, STORAGE, AND PROTECTION

1.08 (NOT USED)

1.09 (NOT USED)

1.10 (NOT USED)

PART 2 - PRODUCTS

2.1 (NOT USED)

2.2 (NOT USED)

2.3 (NOT USED)

2.4 SOURCE QUALITY CONTROL

A. Factory Demonstration Test - General:
1. Before shipment to the project site, the complete PCIS system including all operator stations, servers, network equipment, printers, PCMs, PLCs, RTUs, LCPs, CCS, peripherals, communications equipment, and other SCADA equipment, shall be assembled, connected, and all software loaded for a full functional Factory Demonstration Test (FDT) of the integrated system.
2. Perform tests to show that the integrated system hardware and software is fully operational and in compliance with the requirements of the Contract Documents.
3. Additional factory tests are specified in other sections of Division 16.
4. The CONTRACTOR’s test personnel shall be responsible for performing tests and recording results.

5. The FDT will be witnessed by the ENGINEER and/or other representatives of the OWNER.
6. Right of Observation: The OWNER retains the right to observe all factory test activities including any and all subsystem preparation, pretests, troubleshooting, retests, warm-up, and software modification and/or update.
7. The OWNER reserves the right to test any specified function, whether or not explicitly stated in the test submittal.
8. Costs for Repeating Testing: The CONTRACTOR shall pay for ENGINEER's and other OWNER's representatives' travel, subsistence, for witnessing the repetition of failed tests.
9. Correction of Deficiencies: Any deficiencies observed during the test shall be corrected and retested before completion of the test.
10. Any changes and/or corrections shall be noted on the test forms. ENGINEER shall witness the revisions and/or corrections prior to leaving the test site.
11. If the corrections and/or revisions are too extensive to be made while the ENGINEER is scheduled to be at the FDT test site, the FDT shall be, at the ENGINEER's sole discretion, considered failed, and the test shall be restarted at a later date. All costs for the re-test shall be borne by the CONTRACTOR.

B. Testing Simulation:
1. The FDT shall make use of hardware simulators that contain switches, pilot lights, variable analog signal generators, and analog signal level displays, which shall be connected to the I/O points within the SCADA System. All inputs and outputs shall be simulated and proper control and system operation shall be validated. Each switch, pilot light, display, etc. shall be labeled in accordance with the P&IDs so that a timely and thorough test of the complete system can be conducted.
2. The use of jumper wires, terminal block mounted pilot lights, and loose meters to act as or supply the functionality of a simulator shall not be allowed.
3. The hardware simulator may consist of a PLC, operating under a SCADA software package, or other approved software that has its I/O points wired to PLC's I/O points. Software operating on a PC may then act as the switches, pilot lights, variable analog signal generators, and analog signal level displays.

C. Panel Inspections:
1. The ENGINEER to inspect each control panel for completeness, workmanship, fit and finish, and compliance with the Contract Documents and the approved shop drawings.
2. Provide panel inspection forms as part of the Factory Demonstration Test procedures submittal.
3. Inspection to include, as a minimum: layout, mounting, wire and data cable routing, wire tags, power supply, components and wiring, I/O components layout (including terminals, wiring and relays), device layout on doors and front panels, and proper ventilation operation.

D. I/O Test:
1. Verify that I/O is properly wired to field terminals and is properly mapped into the PLC and the rest of the SCADA system, including all operator interface devices.

2. Test Methodology:
   a. Use the submitted and approved system simulator for this test.
   b. Discrete inputs: Apply appropriate input from simulator at panel terminal, observe input card indicator, observe data value at each indicated data address, observe data received on all operator interface displays (SCADA workstations and human machine interface (HMI) displays).
   c. Discrete outputs: Issue commands from operator interface screen to verify output card indicator light and measure response on simulator.
   d. Analog inputs: Apply appropriate analog input signal at panel terminals on simulator, observe data value at each indicated data address, and observe data properly received at each operator screen. Check each point at 0 percent, 50 percent, and 100 percent of scale.
   e. Analog outputs: Enter scaled values in the output buffer file, observe the output data file value, and measure appropriate response on simulator.
3. Test forms to include, but not be limited to:
   a. PLC and panel number.
   b. I/O Type.
   c. I/O tag name.
   d. Panel terminal block numbers.
   e. Rack/slot/number of I/O point.
   f. Check-off for correct response for each I/O point.
   g. Space for comments.
   h. Initial of individual performing test.
   i. Date test was performed.
   j. Witness' signature lines.

E. System Configuration Test:
   1. Demonstrate and test the setup and configuration of all operator stations, servers, development stations, and peripherals.
   2. Demonstrate all utility software and functions, such as virus protection, backup, optical drive burning, network monitoring, etc.
   3. Demonstrate the proper operation of all peripheral hardware.
   4. Demonstrate all general SCADA functions.
   5. Demonstrate proper operation of log-on and other access security functions.
   6. Test automatic fail over of redundant equipment.
   7. Test Forms:
      a. For each test, list the specification page and paragraph of the function demonstrated, and provide a description of the function.
      b. List the specific tests and steps to be conducted.
      c. For each function, list all of the different sub-functions or ways the function can be used, and provide a test check-off for each:
         1) Include signature and date lines.

F. Post-testing:
   1. After installing the cable and connectors, test all cables using the LAN certification to confirm the installation meets the requirements of the specification.

2. Provide test documentation that includes the cable number, total length of cable, a permanent hard copy, as well as an ASCII-formatted diskette copy of all traces.
3. After installing connectors:
   a. Perform cable end-to-end testing on all installed cables from both ends of the cable. Test shall include cable system performance tests and confirm the absence of wiring errors.
   b. Submit a signed test report presenting the results of the cable testing.
   c. Repair or replace any portions of the system not meeting TIA standards for a Category 5e installation. Repaired sections shall be retested.
   d. Submit 3 copies of all final documentation (including traces), using the approved test form, to the ENGINEER upon successful completion of the testing.

PART 3 - PRODUCTS

3.1 (NOT USED)

3.2 (NOT USED)

3.3 <u>INSTALLATION</u>

3.4 <u>FIELD QUALITY CONTROL</u>

A. General:
   1. The OWNER reserves the right to test any specified function, whether or not explicitly stated in the test submittals.
   2. Failure Testing:
      a) In addition to demonstrating correct operation of all specified features, demonstrate how the system reacts and recovers from abnormal conditions including, but not limited to:
         1) Equipment failure.
         2) Operator error.
         3) Communications sub-system error.
         4) Power failure.
         5) Process equipment failure.
         6) High system loading conditions.
   3. Conduct testing Monday through Friday during normal working hours for no more than 8 hours per day. Testing at other times requires approval of the ENGINEER.

B. Manufacturer Services:

C. Sequencing:
   1. See additional requirements in Article 1.09, Sequencing.

D. Calibration:

1. After installation but before starting other tests, calibrate and adjust all instruments, devices, valves, and system, in conformance with the component Manufacturer's instructions and in accordance with these Specifications.
2. Components having adjustable features are to be set carefully for the specific conditions and applications of this installation. Test and verify that components and/or systems are within the specified limits of accuracy.
3. Replace either individually or within a system, defective elements that cannot achieve proper calibration or accuracy.
4. Calibration Points:
    - a) Calibrate each analog instrument at 0 percent, 25 percent, 50 percent, 75 percent, and 100 percent of span, using test instruments with accuracies traceable to National Institute of Testing Standards.
5. Field verify calibration of instruments that have been factory-calibrated to determine whether any of the calibrations are in need of adjustment.
6. Analyzer Calibration:
    - a) Calibrate and test each analyzer system as a workable system after installation. Follow the testing procedures directed by the Manufacturers' technical representatives.
7. Complete instrument calibration sheets for every field instrument and analyzer.
8. Calibration Tags:
    - a) Attach a calibration and testing tag to each instrument, piece of equipment, or system.
    - b) Sign the tag when calibration is complete.

E. Industrial Network Testing:

1. Test remote operation.
    - a) Verify and use HMIs, (if present) and confirm the proper operation of the field device:
    - b) Stroke valves through outputs from the SCADA System, and confirm proper directional operation. Confirm travel limits and any feedback signals to the SCADA System.
    - c) Exercise motors starters from the SCADA System and verify proper operation through direct field observation.
    - d) Exercise solenoids and other field devices from the SCADA System and verify proper operation through direct field observation.
2. Include in the test forms:
    - a) Analog input devices:
        - 1) Calibration range.
        - 2) Calibration data: Input, output, and error at each test value.
        - 3) Analog input associated PLC register address.
        - 4) Value in PLC register at each test point.
        - 5) Value displayed at each operator interface station (human machine interface displays and SCADA workstations).
    - b) Analog output devices:
        - 1) Calibration range.
        - 2) Test value at each test point.
        - 3) Analog output associated PLC register address.
        - 4) Control variable value at field device at each test point.

5) Physical device response at each test point: Response to be actual valve position, or motor speed, etc.

c) Discrete instrument input devices:

1) Switch setting, contact action, and dead band.
2) Valve position switches: Response in the PLC as the valve is stroked from the PLC. Field observed actual valve position, and valve indicator position as the valve is stroked from the PLC.
3) Operator interface switches (control stations and other pilot devices) and associated response.
4) Starter and drive auxiliary device contact response.
5) Response of all other discrete inputs to the PLC.

d) Discrete output devices:

1) Observed response of field device to the discrete output from the PLC.
2) Observe the proper operation of Open, Close, Start, Stop, On, Off, etc.

e) Test equipment used and associated serial numbers.

F. Solids Handling Building HVAC testing and balancing.

1. ICSC shall provide support during HVAC testing and balancing.

3.5 (NOT USED)

3.6 (NOT USED)

3.7 DEMONSTRATION AND TRAINING

A. Performance/Reliability/Operational Tests:

1. After successful completion of the pre-commissioning test as accepted by the ENGINEER and OWNER, the performance test can proceed.
2. Complete training and instruction of the OWNER's personnel in conformance with paragraph 1.09 Sequencing and Scheduling.

B. The Performance Test may be performed concurrently with the 7-Day Operational Test.

C. General:

1. The performance test is part of the Work that must be completed as a condition of substantial completion for the entire project.
2. The complete PLC control and SCADA system must run continuously for the duration of the performance test. During this period, exercise all system functions, and log for cause of failure, any system interruption and accompanying component, subsystem, or program failure:
   a) Include time of occurrence and duration of each failure.
3. Provide a competently trained technician or programmer on call for the project site during all normal working days and hours from the start of the performance test until final acceptance of the system. Response time to the project site:
   a) 24 hours or less, for a major failure.
4. The Performance Test duration:
   a) 7 days.

5. Test and use; the entire process control system under standard operating conditions.

D. Failures:

1. Classify failures as either major or minor.
    a) Minor Failure:
        1) A small and non-critical component failure or software problem that can be corrected by the OWNER's operators.
        2) Log this occurrence but this is not a reason for stopping the test and is not grounds for non-acceptance.
        3) Should the same or similar component failure occur repeatedly, this may be considered as grounds for non-acceptance.
        4) Failure of one printer, or operator station is considered a minor failure providing all functions can be provided by backup equipment, i.e. alternate printers and operator station, and repairs can be made and equipment returned to service within 3 working days.
    b) Major Failure:
        1) Considered to have occurred when a component, subsystem, software control, or program fault causes a halt in or improper operation of the system and/or when a technician's work is required to make a repair or to re-initiate operation of the system.
        2) Cause termination of the performance test.
        3) Start a new acceptance test when the causes of a major failure have been corrected.
        4) A failure is also considered major when failure of any control system that results in an overflow, underflow, overdose, or under dose condition occurs.

E. Technician Report:

1. Each time a technician is required to respond to a system malfunction he or she must complete a report which includes details concerning the nature of the complaint or malfunction and the resulting repair action required and taken.
2. If a malfunction occurs which clears itself or which the operator on duty is able to correct, no report is required or logged as specified above.
3. If a technician has performed work but no report is written, then a major failure is considered to have occurred.
4. Each report shall be submitted within 24 hours to the ENGINEER and the OWNER, or its representative.

3.8 (NOT USED)

3.9 <u>SCHEDULES</u>

A. Example Test Forms:

1. Example test forms are attached at the end of this Section. They may be used as a starting point for the development of project-specific test forms for this project.

2. The example test forms are not intended to be complete or comprehensive. Edit and supplement the forms to meet the requirements for testing and test forms specified in this Section and other Contract Documents.

		INSTALLATION AND CERTIFICATION CHECKLIST DOCUMENTATION	

INSTRUMENT LOOP NO. ______________________________

SERVICE DESCRIPTION ______________________________

A COPY OF LATEST ISSUE OF THE FOLLOWING DOCUMENTS ARE INCLUDED IN THIS INSTRUMENT INSTALLATION CERTIFICATION FILE:

- ☐ INSTRUMENT SPECIFICATION SHEETS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT INSTALLATION DETAILS (FOR ALL INSTRUMENTS IN THE LOOP)
- ☐ INSTRUMENT LOOP WIRING DIAGRAMS
- ☐ INSTRUMENT INSTALLATION CERTIFICATION CHECKLIST
- ☐ SIZING CALCULATIONS
- ☐ INSTRUMENT INSTALLATION SCHEDULE (APPLICABLE PART)
- ☐ NAMEPLATE SCHEDULE (APPLICABLE PART)
- ☐ VENDOR LITERATURE CALIBRATION INFORMATION

INSTRUMENT LOOP IS PART OF AN EQUIPMENT START UP/SHUTDOWN INTERLOCKS? ☐ No ☐ Yes

REMARKS: ______________________________

CHECKED BY (COMPANY) ____________ ACCEPTED BY (COMPANY) ____________

SIGNATURE ____________ SIGNATURE ____________

DATE ____________ DATE ____________

		SWITCHES INSTALLATION AND CALIBRATION CHECKLIST	

INSTRUMENT LOOP NO. ____________

SERVICE DESCRIPTION ____________

CHECK BELOW, WHEN COMPLETED:

- ☐ BENCH CALIBRATED PER SPEC SHEET
- ☐ VERIFIED PER P&ID NO
- ☐ CORRESPONDS TO SPECIFICATION SHEET NO.
- ☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO.
- ☐ INSTALLATION CORRECT PER DETAIL NO.
- ☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED
- ☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL
- ☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

INSTRUMENT LOOP IS PART OF AN EQUIPMENT START UP/SHUTDOWN INTERLOCKS? ☐ No ☐ Yes

FIELD CALIBRATION CHECK							
CONTACT NO.	FUNCTION	FOR SIGNAL	CONTACT IS TO	AT SPECIFIED VALUE FOR		ACTUAL TRIP POINT WAS…	
1	☐ ALARM	☐ INCR	☐ OPEN	SET PT =	________	SET PT =	________
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET =	________	RESET =	________
2	☐ ALARM	☐ INCR	☐ OPEN	SET PT =	________	SET PT =	________
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET =	________	RESET =	________
3	☐ ALARM	☐ INCR	☐ OPEN	SET PT =	________	SET PT =	________
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET =	________	RESET =	________
4	☐ ALARM	☐ INCR	☐ OPEN	SET PT =	________	SET PT =	________
	☐ S/D PERM	☐ DECR	☐ CLOSE	RESET =		RESET =	

NOTE: PERM IS ABBREVIATED FOR PERMISSIVE

		SWITCHES INSTALLATION AND CALIBRATION CHECKLIST	

REMARKS:

CHECKED BY (COMPANY)	
SIGNATURE	
DATE	

ACCEPTED BY (COMPANY)	
SIGNATURE	
DATE	

		TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST	

INSTRUMENT LOOP IS PART OF AN EQUIPMENT START UP/SHUTDOWN INTERLOCKS? ☐ No ☐ Yes

INSTRUMENT TYPE ☐ TRANSMITTER ☐ CONTROLLER ☐ INDICATOR

☐ OTHER DESCRIPTION

INSTRUMENT TAG NO. ______ SERIAL NO. ______

SERVICE DESCRIPTION ______

BENCH CALIBRATION CHECK				
INPUT RANGE =			OUTPUT RANGE =	
HEAD CORRECTION =			☐ LINEAR	
CALIBRATED SPAN =			☐ SQUARE ROOT	
% CALIB SPAN	DESIRED VALUE	ACTUAL VALUE	EXPECTED VALUE	ACTUAL VALUE
0				
50				
100				

CHECK BELOW, WHEN COMPLETED:

☐ BENCH CALIBRATED PER SPEC SHEET ______

☐ VERIFIED PER P&ID NO ______________________

☐ CORRESPONDS TO SPECIFICATION SHEET NO. ______________________

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. ______________________

☐ INSTALLATION CORRECT PER DETAIL NO. ______________________

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

<table>
<tr><td colspan="5" align="center"><u>FIELD CALIBRATION CHECK</u></td></tr>
<tr><td colspan="3">INPUT RANGE =</td><td colspan="2">OUTPUT RANGE =</td></tr>
<tr><td>% CALIB SPAN</td><td>DESIRED VALUE</td><td>ACTUAL VALUE</td><td>EXPECTED VALUE</td><td>ACTUAL VALUE</td></tr>
<tr><td>0</td><td></td><td></td><td></td><td></td></tr>
<tr><td>50</td><td></td><td></td><td></td><td></td></tr>
<tr><td>100</td><td></td><td></td><td></td><td></td></tr>
</table>

<table>
<tr><td colspan="2"></td><td rowspan="2">TRANSMITTER/CONTROLLER/INDICATOR INSTALLATION AND CALIBRATION CHECKLIST</td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

☐ DIRECT ☐ REVERSE

☐ ACTION VERIFIED AT 50% SPAN

☐ ACTION VERIFIED AT _________ SPAN

CONTROLLER SETTINGS

SETTING	GAIN	PB	RESET (INTEGRAL)	DERIV. (RATE)	HIGH LIMIT	LOW LIMIT	ELEV. ZERO	ZERO SUPP
PRE-TUNE								
POST-TUNE								

PRE-TUNE SETTINGS

	GAIN	PB	RESET (REPEAT/MIN)	RESET (MIN/REPEAT)	DERIVATION (MINUTES)
FLOW:	1.0	100	10	0.1	N/A
LEVEL	1.0	100	MIN.	MAX.	N/A
PRESSURE	2.0	50	2.0	0.5	N/A
TEMP.	4.0	25	0.1	10	OFF

REMARKS ____

____

____

____

____

____

____

____

____

CHECKED BY (COMPANY) ____________________ ACCEPTED BY (COMPANY) ____________________

SIGNATURE ____________________ SIGNATURE ____________________

DATE ____________________ DATE ____________________

		ANALYZERS INSTALLATION AND CALIBRATION CHECKLIST	

☐ ☐

INSTRUMENT LOOP IS PART OF AN EQUIPMENT START UP/SHUTDOWN INTERLOCKS? NO YES

TYPE OF INSTRUMENT ____

INSTRUMENT TAG NO. ______________________ SERIAL NO. ______________________

SERVICE DESCRIPTION ____

CHECK BELOW, IF TRUE:

☐ BENCH CALIBRATED PER SPEC SHEET

☐ VERIFIED PER P&ID NO. ____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. ______________________________

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. ______________________

☐ INSTALLATION CORRECT PER DETAIL NO. ______________________________

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

REMARKS ____

CHECKED BY (COMPANY) ____________________ ACCEPTED BY (COMPANY) ____________________

SIGNATURE ________________________________ SIGNATURE ________________________________

DATE ____________________________________ DATE ____________________________________

		CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST	

☐ ☐

INSTRUMENT LOOP IS PART OF AN EQUIPMENT START UP/SHUTDOWN INTERLOCKS? NO YES

VALVE TAG NO. ______________________________ SERIAL NO. ____________________

☐ TRANSDUCER TAG NO. ____________________ SERIAL NO. ____________________

☐ SOLENOID TAG NO. ____________________ SERIAL NO. ____________________

☐ VOLUME BOOSTER TAG NO. ________________ SERIAL NO. ____________________

☐ POSITIONER SERIAL NO. ________________________

SERVICE DESCRIPTION

____

TRANSDUCER CHECK

INPUT RANGE =			OUTPUT RANGE =		
CALIBRATED SPAN =			CALIBRATED SPAN =		
BENCH					
SPAN	DESIRED	ACTUAL	SPAN	EXPECTED	ACTUAL
0%			0%		
50%			50%		
100%			100%		
FIELD					
SPAN	DESIRED	ACTUAL	SPAN	EXPECTED	ACTUAL
0%			0%		
50%			50%		
100%			100%		

CHECK BELOW, IF TRUE:

☐ BENCH CALIBRATED PER ABOVE

☐ VERIFIED PER P&ID NO. ____

☐ CORRESPONDS TO SPECIFICATION SHEET NO. ____________________________

☐ VALVE SPECIFICATION NO. ______________________________

☐ TRANSDUCER SPECIFICATION NO. ______________________________

☐ SOLENOID SPECIFICATION NO. ______________________________

☐ WIRING CORRECT PER INSTRUMENT LOOP DRAWING NO. ______________________________

☐ INSTALLATION CORRECT PER INSTRUMENT INSTALLATION DETAILS______________________

☐ VALVE DETAIL NO. ______________________________

☐ TRANSDUCER DETAIL NO. ______________________________

☐ SOLENOID DETAIL NO. ______________________________

		CONTROL VALVES INSTALLATION AND CALIBRATION CHECKLIST	

☐ ACCESSORIES ARE PRESENT AND PROPERLY INSTALLED

☐ INSTRUMENT IS ACCESSIBLE FOR MAINTENANCE OR REMOVAL

☐ ENGRAVED LAMINATED NAMEPLATE (NO SPELLING ERRORS) PERMANENTLY INSTALLED

VALVE CHECK

FLOW CHECK	☐ PROCESS FLOW DIRECTION THRU THE VALVE IS CORRECT		
SAFETY CHECK	ON LOSS OF AIR VALVE FAILS ☐ OPEN ☐ CLOSE	ON LOSS OF POWER SOLENOID FAILS ☐ TO VENT ☐ TO VALVE	
]TRAVEL CHECK	FULL OPEN AT ____________________ PSI	FULL CLOSED AT ____________________ PSI	MEASURED TRAVEL ____________________ INCHES
SEATING CHECK	☐ ON BENCH ☐ IN-LINE	RESULTS	ACTUATOR BENCH SET

POSITIONER CHECK

VALVE FULL OPEN AT ______________________________ PSI TO POSITIONER

VALVE FULL CLOSED AT ______________________________ PSI TO POSITIONER

VOLUME BOOSTER CHECK

BYPASS VALVE (GAIN) ADJUSTING SCREW BACKED OUT __________ TURNS FROM CLOSED TO ENSURE QUICK BUT STABLE OPERATION (TYPICALLY 1-1/2 TO 2 TURNS)

REMARKS
____

____

____

____

____

____

CHECKED BY (COMPANY) ____________________ ACCEPTED BY (COMPANY) ___________________

SIGNATURE _________________________________ SIGNATURE _________________________________

DATE _____________________________________ DATE _____________________________________

END OF SECTION

SECTION 16484
MOTOR STARTERS

PART 1 - GENERAL

1.1 SCOPE

Furnish all labor, materials, equipment, appliances, and perform all operations in connection with, and complete in strict accordance with, this section of specifications and the applicable drawings and subject to the terms and conditions of the contract for the following work:

A. Motor Control Systems.

1.2 APPLICABLE SECTIONS

A. The General Conditions, Supplementary Conditions, Special Conditions, Alternates and Addenda, applicable drawings and the technical specifications herein shall apply to all work under this Division 16, including but not limited to the following:

1. Section “Electrical General Requirement”.
2. Section “Fuses”.
3. Section “Grounding and Bonding”.
4. Section “Control Devices”.

B. The CONTRACTOR shall be familiar with all sections of these electrical specifications. He shall adapt his work to the work required of other trades to affect a complete and working system. Where this CONTRACTOR furnishes equipment, materials or installation which comprises a part of another CONTRACTOR's system, the item so furnished shall meet or exceed the requirements imposed on the other systems.

1.3 SHOP DRAWINGS/SUBMITTALS

A. Furnish complete working shop drawings of all control systems. Reference design documents for sequence, basic components, suggested piping, wiring, and dimensions. Submit manufacturer's data sheets for all equipment, devices and materials.

B. After initial review, make corrections requested and resubmit in clean format. Work only from final review set.

C. Maintain Record Drawings in the field. Clean up originals at completion of work and resubmit for OWNER's use in operation of the systems.

1.1 CONTROL DIAGRAMS

A. Control diagrams indicating the general control strategy are as shown on the Drawings. Actual circuitry will vary for the specific equipment furnished. Pilot light push-to-test wiring was omitted from the control diagrams for clarity.

B. Clarification of any function or device of any system not fully understood or recognized as being undefined should be requested from the ENGINEER during the bidding period.

1.4 CLEANING AND LUBRICATION

All equipment shall be thoroughly cleaned by the CONTRACTOR before final acceptance. The CONTRACTOR shall provide lubrication for all equipment furnished by him.

1.5 TESTING AND ADJUSTING OF SYSTEM

A. During the testing and adjusting of the various electrical, control, and instrumentation systems, the CONTRACTOR shall have a representative present and available to adjust controls as required. The integrity and accuracy of each function and control point shall be demonstrated and reported.

1.6 CODES AND STANDARDS

A. The following standards shall be considered to be part of this specification insofar as they give definitions and describe requirements and tests which equipment supplied shall meet. They shall be the latest edition, including any addenda, supplements, or revisions thereto, in effect at the time of award of the purchase order. The equipment shall also meet any laws or requirements of the city, state or other regulatory bodies having jurisdiction over such apparatus, unless otherwise specified.

1. ANSI C57.13 Requirements for Instrument Transformers

ANSI C89.1 (NEMA ST1) Specialty Transformers (except General Purpose Type)

3. NEMA AB-1 Molded Case Circuit Breakers

NEMA ICS1 General Standards for Industrial Control and Systems

NEMA 1CS2 Industrial Control Devices, Controllers and Assemblies

6. ANSI C1 (NFPA70) National Electrical Code

UL 489 Molded Case Circuit Breakers and Circuit Breaker Enclosures

8. UL 508 Industrial Control Equipment

9. UL 845 Standard for Motor Control Centers

10. UL 1053 Ground Fault Sensing and Relaying Equipment

11. MSHA Mine Safety and Health Administration

PART 2 - PRODUCTS

2.1 MOTOR CONTROLS NOT IN MOTOR CONTROL CENTERS

A. Furnish NEMA 4X stainless steel with gasketed hinged door control cabinets to protect and conceal all control devices. Arrange components neatly to provide adequate maintenance opportunity and proper device function. Label all components, numerically code all piping and wiring. Terminate all wiring at labeled terminal blocks. Provide engraved plastic labels for all panel face devices.

2.2 MOTOR STARTERS NOT IN MOTOR CONTROL CENTER

A. Furnish stainless steel with gasketed hinged door control cabinets to protect and conceal all control devices. Arrange components neatly to provide adequate maintenance opportunity and proper device function. Label all components, numerically code all piping and wiring. Terminate all wiring at terminal blocks. Provide engraved plastic labels for all panel face devices.

A. Combination magnetic starters shall be sized as indicated on the Drawings and shall be equipped as follows:

1. Motor Circuit Protector.
2. NEMA contactor rating indicated, NEMA size 1 minimum.
3. Control power transformer sized per load installed plus 50% spare capacity. Shall include fused primary and secondary.
4. Solid state overload relay – SymCom Motor Saver 777, Square D Motor Logic Plus, or Ge Multilin, Allen Bradley or equal.
5. Pilot devices and controls as shown on Drawings.
6. NEMA rated enclosure as shown on the Drawings.

C. Manual motor starters shall have:

1. ON pilot light.
2. Overload Protection: Melting alloy type thermal overload relays where indicated or required.
3. NEMA rated enclosure as shown on the Drawings.

PART 3 - EXECUTION

3.1 WIRING

A. All control wiring, 120 volt and below, shall be installed in conduit and wiring boxes.

B. Use no wiring smaller than #14 AWG and no conduit smaller than ¾ inch.

3.2 SPARES

A. Provide one spare manual motor starter for each size and type used.

B. Provide one NEMA size 1 contactor.

END OF SECTION

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SECTION 16491
FUSES

PART 1 - GENERAL

1.1 <u>SCOPE</u>

A. Furnish all labor, materials, equipment, appliances, and perform all operations in connection with, and complete in strict accordance with, this section of specifications and the applicable drawings and subject to the terms and conditions of the contract for the following work:

B. Fuses.

C. Spare Fuse Cabinet.

1.2 <u>APPLICABLE SECTIONS</u>

A. The General Conditions, Supplementary General Conditions, Special Conditions, Alternates and Addenda, applicable drawings and the technical specifications including but not limited to the following:

1. Section “Electrical General Requirements”.

2. Section “Conductors and Cables”.

1.3 <u>ACCEPTABLE MANUFACTURERS</u>

A. Manufacturer: Bussmann.

B. Other acceptable manufacturers: Gould Shawmut, Little Fuse.

C. All fuses shall be of one manufacturer. Fuses shall have a 200,000 ampere RMS symmetrical interrupting rating unless noted otherwise.

PART 2 - PRODUCTS

2.1 <u>FUSE TYPES AND RATINGS</u>

A. Fuses from 0 to 600 ampere for each circuit serving a single motor shall be UL Class RK5 dual-element Low Peak, LPN-RK (250 volt), LPS-RK (600 Volt).

B. All other fuses in the 0 to 600 ampere range shall be UL Class RK5, dual-element, time delay, Iow peak, LPN-RK (250 volt), LPS-RK (600 Volt).

C. Fuses larger than 600 ampere shall be UL Class L with time delay, Hi Cap, KRP-C.

D. High voltage fuses - see drawings.

PART 3 - EXECUTION

3.1 <u>INSTALLATION</u>

A. Motor circuits shall be fused. Fuses, 0 to 600 amperes, for 1.15 service factor motors shall be sized not exceeding 125% of motor full load amperes shown on nameplate. Fuses, 0 to 600 amperes, for all other motors shall be sized not exceeding 115% of motor full load amperes. Fuses above 600 amperes for all motors shall be sized up to 150% of motor full load amperes. Abnormal motor starting conditions requiring over sizing shall be coordinated with motor manufacturer.

B. Spare fuses shall be furnished for all fuse types. Spares shall amount to 10% of installed fuses with a minimum of one set of each fuse type and ampere rating. The set shall equal the number of poles in the appropriate switch.

C. Provide Spare Fuse Cabinet equal to Bussmann for storing spare fuses. Mount on wall in Equipment Room as directed by the ENGINEER.

END OF SECTION

SECTION 16510
INTERIOR LUMINAIRES

PART 1 - GENERAL

1.01 SCOPE

A. Furnish all labor, materials, equipment, appliances and perform all operations in connection with, and complete in strict accordance with, this section of specifications and the applicable drawings and subject to the terms and conditions of the contract for the following work:

1. Interior luminaires and accessories.
2. Emergency lighting units.
3. Exit signs.
4. Ballasts.
5. Fluorescent lamp emergency power supply.
6. Lamps.
7. Luminaire accessories.

1.02 APPLICABLE SECTIONS

A. The General Conditions, Supplementary General Conditions, alternates and Addenda, applicable drawings and the technical specification including but not limited to the following;

B. Section “Electrical General Requirements”.

1.03 REFERENCES

A. ANSI C78.379 - Electric Lamps - Incandescent and Issued October 1993 High-Intensity Discharge Reflector Lamps - Classification of Beam Patterns.

B. ANSI C82.1 - Ballasts for Fluorescent Lamps -Specifications.

C. ANSI C82.4 - Ballasts for High-Intensity Discharge and Low Pressure Sodium Lamps (Multiple Supply Type).

D. NEMA WD 6 - Wiring Devices-Dimensional Requirements.

E. NFPA 70 - National Electrical Code.

F. NFPA 101 - Life Safety Code.

1.04 SUBMITTALS FOR REVIEW

A. Section “Electrical General Requirements”.

B. Shop Drawings: Indicate dimensions and components for each luminaire that is not a standard product of the manufacturer.

C. Product Data: Provide dimensions, ratings, and performance data.

1.05 SUBMITTALS FOR CLOSEOUT

A. Section “Electrical General Requirements”.

B. Submit manufacturer's operation and maintenance instructions for each product.

1.06 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum five years documented experience.

1.07 REGULATORY REQUIREMENTS

A. Conform to requirements of NFPA 70.

B. Conform to requirements of NFPA 101.

C. Products: Listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

1.08 EXTRA PRODUCTS

A. Section “Contract Closeout”.

B. Furnish 10% or a minimum of two of each lens type.

C. Furnish one case of replacement fluorescent lamps for each lamp type. Furnish two replacement lamps for each size HID lamp type and LED assembly.

D. Furnish 10% or a minimum of two of each ballast type or driver type.

PART 2 - PRODUCTS

2.01 LUMINAIRES

A. Furnish Products as scheduled.

B. Lighting Fixtures: Shall be as shown in the Lighting Fixture Schedule on the Drawings.

2.02 LAMPS

A. LAMPS: shall be provided for all lighting fixtures in accordance with the lighting fixtures schedule on the drawings. All lamps shall be new at time of final inspection and shall be manufactured by one of the following:

1. General Electric
2. Venture Lighting International
3. Phillips
4. Osram-Sylvania
5. As found in Schedules

B. Lamp Types: As specified for luminaire.

2.03 NOT USED

2.04 LED LUMINAIRE WARRANTY

A. Provide a written 5-year on-site replacement warranty for material, fixture finish, and workmanship. On-site replacement includes transportation, removal, and installation of new products.

1. Include finish warranty to include failure and substantial deterioration such as blistering, cracking, peeling, chalking, or fading.
2. Material warranty must include:
   a. All drivers.
   b. Replacement when more than 10 percent of LED sources in any lightbar or subassembly(s) are defective or non-starting.

B. Warranty period must begin on date of beneficial occupancy. Provide the Contracting Officer with signed warranty certificates prior to final payment.

2.05 PROVIDE LUMINAIRE USEFUL LIFE CERTIFICATE

A. Submit certification from the manufacturer indicating the expected useful life of the luminaires provided. The useful life must be directly correlated from the IES LM-80 test data using procedures outlined in IES TM-21. Thermal properties of the specific luminaire and local ambient operating temperature and conditions must be taken into consideration.

2.06 LUMINAIRES

A. UL 1598, NEMA C82.77, and UL 8750. Provide luminaires as indicated in luminaire schedule and NL plates or details on project plans. Provide luminaires complete with light sources of quantity, type, and wattage indicated. Provide all luminaires of the same type by the same manufacturer. Luminaires must be specifically designed for use with the driver, ballast or generator and light source provided.

2.07 LED LUMINAIRES

A. Provide luminaires complete with power supplies (drivers) and light sources. Provide design information including lumen output and design life in luminaire schedule on project plans for LED luminaires. LED luminaires must meet the minimum requirements in the following table:

B. LED luminaires must also meet the following minimum requirements:

LUMINAIRE TYPE	MINIMUM LUMINAIRE EFFICACY (LE)	MINIMUM COLOR RENDERING INDEX (CRI)
LED TROFFER – 1 x 4300 x 1200 2 x 2600 x 600 2 x 4600 x 1200	90 LPW	80
LED Downlight	50 LPW	90
LED Track or Accent	40 LPW	80
LED Low Bay/High Bay	80 LPW	70
LED Linear Ambient	80 LPW	80

a. Luminaires must have a minimum 5-year manufacturer's warranty.

b. Luminaires must have a minimum L70 lumen maintenance value of 50,000 hours as calculated by IES TM-21, with data obtained per IES LM-80 requirements.

c. Luminaire drive current value must be identical to that provided by test data for luminaire in question.

d. Luminaires must be tested to IES LM-79 and IES LM-80 standards, with the results provided as required in the Submittals paragraph of this specification.

2.08 NOT USED

2.09 NOT USED

2.10 NOT USED

2.11 LUMINAIRES FOR HAZARDOUS LOCATIONS

In addition to requirements stated herein, provide LED luminaires for hazardous locations which conform to UL 844 or which have Factory Mutual certification for the class and division indicated.

2.12 DRIVERS, BALLASTS AND GENERATORS

2.13 LED DRIVERS

NEMA SSL 1, UL 8750. LED drivers must be electronic, UL Class 1, constant-current type and comply with the following requirements:

a. Output power (watts)and luminous flux (lumens) as shown in luminaire schedule for each luminaire type to meet minimum luminaire efficacy (LE) value provided.

b. Factor (PF) greater than or equal to 0.9 over the full dimming range when provided.

c. Current draw Total Harmonic Distortion (THD) of less than 20 percent.

d. Class A sound rating.

e. Operable at input voltage of 120-277 volts at 60 hertz.

f. Minimum 5-year manufacturer's warranty.

g. RoHS compliant.

h. Integral thermal protection that reduces or eliminates the output power if case temperature exceeds a value detrimental to the driver.

i. UL listed for dry or damp locations typical of interior installations.

j. Non-dimmable, or fully-dimmable to 1% using 0-10V, or 3 wire, control as indicated in luminaire schedule and on drawings.

2.14 NOT USED

2.15 NOT USED

2.16 LIGHT SOURCES

NEMA ANSLG C78.377, NEMA SSL 3. Provide type and wattage as indicated in luminaire schedule on project plans.

A. LED Light Sources

a. Correlated Color Temperature (CCT) of 3000 or 4000 degrees K as indicated.

b. Minimum Color Rendering Index (CRI) R9 value of 80.

c. High power, white light output utilizing phosphor conversion (PC) process or mixed system of colored LEDs, typically red, green and blue (RGB).

d. RoHS compliant.

e. Provide light source color consistency by utilizing a binning tolerance within a 3 step McAdam ellipse.

2.17 CONTROLS

A. Dual Technology Wall Mounted Occupancy Sensors: Spaces indicated on drawings shall be equipped with a dual technology occupancy sensor DT-100L as manufacturer by Wattstopper. The sensors shall be connected to a power supply as specified above. The sensor shall comply with the following specifications:

a. Shall utilize PIR and Ultrasonic technologies with an adjustable integrated light level sensor for 2.5 to 430 foot-candles. The output shall be a single-pole, double-throw isolated relay.

b. Shall utilize 40Khz +/- .006% ultrasonic frequency.

c. Shall provide an adjustable time delay of 15 seconds to 15 minutes and an LED indicator for both technologies.

d. Shall provide adjustable sensitivities, and shall be capable of installing two units per power pack.

e. Shall be UL listed with a 5 year warranty.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install suspended luminaires using pendants supported from swivel hangers. Provide pendant length required to suspend luminaire at indicated height.

B. Support luminaires independent of ceiling grid, if layin type ceilings or concealed spline ceilings ore used.

C. Locate recessed ceiling luminaires as indicated on reflected ceiling plan.

D. Install surface mounted luminaires plumb and adjust to align with building lines and with each other. Secure to prevent movement.

3.02 INSTALLATION OF LIGHTING FIXTURES

A. Install all lighting fixtures complete and ready for service, in accordance with the Fixture Schedule on the Drawings:

B. Wire all fixtures with fixture wiring of at least 150 degree C rating. Conductors in wiring channels of fixtures mounted in rows shall be the same size as the circuit wiring supplying the rows.

C. Install all fluorescent fixtures straight and true with reference to adjacent walls.

D. Install all lighting fixtures, including those mounted in continuous rows, so that the weight of the fixture is supported either directly or indirectly by a sound and safe structural member of the building, using adequate number and type of fasteners to ensure a safe installation. Screwed fastenings and toggles through ceiling or wall material are not acceptable. Provide suitable connectors or collars to connect adjoining fixtures in continuous rows.

E. Do not support fixtures from roof deck. Provide unistrut channels spanning space between roof joists to support fixtures and outlets.

F. Fixtures mounted in lay-in grid ceilings shall have safety support wires to structural roof members as detailed for seismic restraint.

G. All single outlets shall be properly centered in each room. Where two or more outlets occur, they shall be spaced uniformly and in straight lines with each other.

H. Provide plaster frames and support channels around ceiling openings for recessed fixtures. Securely fasten to ceiling structural members.

I. Terminate circuits for recessed fixtures in an extension outlet box adjacent to ceiling opening and connect to fixtures with flexible steel conduit.

J. Where lighting fixtures and other electrical items are shown in conflict with locations and structural members and mechanical or other equipment, provide all required supports and wiring to clear the encroachment.

3.03 ADJUSTING

A. Section “Contract Closeout”.

3.04 CLEANING

A. Contract Closeout: Cleaning installed work.

B. Clean electrical parts to remove conductive and deleterious materials.

C. Remove dirt and debris from enclosures.

D. Clean photometric control surfaces as recommended by manufacturer.

E. Clean finishes and touch up damage.

3.05 DEMONSTRATION AND INSTRUCTIONS

A. Section “Contract Closeout” - Starting of Systems: Demonstrating installed work.

B. Demonstrate luminaire operation for 12 hours.

3.06 PROTECTION OF FINISHED WORK

A. Re-lamp or repair/replace luminaires that have failed at substantial completion.

END OF SECTION

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SECTION 16520
AREA LIGHTING

PART 1 - GENERAL

1.01 SCOPE

A. Furnish all labor, materials, equipment, appliances and perform all operations in connection with, and complete in strict accordance with, this section of specifications and the applicable drawings and subject to the terms and conditions of the contract for the following work: Exterior area, façade and landscape lighting.

1.02 APPLICABLE SECTIONS

A. The General Conditions, Supplementary General Conditions, alternates and Addenda, applicable drawings and the technical specification including but not limited to the following;

B. Section “Electrical General Requirements”.

1.03 REFERENCES

(NEW)

1.04 SUBMITTALS FOR REVIEW

A. Section “Electrical General Requirements”.

B. Shop Drawings: Indicate dimensions and components for each luminaire that is not a standard product of the manufacturer.

C. Product Data: Provide dimensions, ratings, and performance data.

1.05 SUBMITTALS FOR CLOSEOUT

A. Section “Electrical General Requirements”.

B. Submit manufacturer's operation and maintenance instructions for each product.

1.06 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum five years documented experience.

1.07 REGULATORY REQUIREMENTS

A. Conform to requirements of NFPA 70.

B. Conform to requirements of NFPA 101.

C. Products: Listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

1.08 EXTRA PRODUCTS

A. Section 260500 - Contract Closeout.

B. Furnish 10% or a minimum of two of each lens type.

C. Furnish one case of replacement fluorescent lamps for each lamp type. Furnish replacement lamps for each size HID lamp type and LED assembly.

D. Furnish 10% or a minimum of two of each ballast type or driver type.

1.09 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 189.1	(2014) Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings
ASHRAE 90.1 - IP	(2013) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE 90.1 - SI	(2013) Energy Standard for Buildings Except Low-Rise Residential Buildings

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2016) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM B108/B108M	(2015) Standard Specification for Aluminum-Alloy Permanent Mold Castings
ASTM B117	(2016) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM C1089	(2013) Standard Specification for Spun Cast Prestressed Concrete Poles
ASTM G154	(2016) Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials

CALIFORNIA ENERGY COMMISSION (CEC)

CEC Title 24	(2008; Effective Jan 2010) California's Energy Efficiency Standards for Residential and Nonresidential Buildings

ILLUMINATING ENGINEERING SOCIETY (IES)

IES HB-10	(2011; Errata 2015) IES Lighting Handbook
IES LM-79	(2008) Electrical and Photometric Measurements of Solid-State Lighting Products
IES LM-80	(2015) Measuring Lumen Maintenance of LED Light Sources
IES RP-16	(2010; Addendum A 2008; Addenda B 2009; Addendum C 2016) Nomenclature and Definitions for Illuminating Engineering
IES RP-8	(2014) Roadway Lighting
IES TM-15	(2011) Luminaire Classification System for Outdoor Luminaires
IES TM-21	(2011; Addendum B 2015) Projecting Long Term Lumen Maintenance of LED Light Sources

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI ANSLG C78.41	(2006) For Electric Lamps--Guidelines for Low-Pressure Sodium Lamps
ANSI ANSLG C78.42	(2009; R 2016) For Electric Lamps: High-Pressure Sodium Lamps
ANSI C136.13	(2004; R 2009) American National Standard for Roadway Lighting Equipment, Metal Brackets for Wood Poles
ANSI C136.21	(2014) American National Standard for Roadway and

	Area Lighting Equipment - Vertical Tenons Used with Post-Top-Mounted Luminaires
ANSI C136.3	(2014) American National Standard for Roadway and Area Lighting Equipment Luminaire Attachments
ANSI C78.1381	(1998) American National Standard for Electric Lamps - 250-Watt, 70 Watt, M85 Metal-Halide Lamps
ANSI C82.4	(2002) American National Standard for Ballasts for High-Intensity-Discharge and Low-Pressure Sodium (LPS) Lamps (Multiple-Supply Type)
ANSI/ANSLG C78.43	(2013) American National Standard for Electric Lamps - Single-Ended Metal-Halide Lamps
ANSI/NEMA C78.LL 1256	(2003; R 2015) Procedures for Fluorescent Lamp Sample Preparation and the Toxicity Characteristic Leaching Procedure (TCLP)
NEMA 250	(2014) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ANSLG C78.377	(2015) American National Standard for Electric Lamps— Specifications for the Chromaticity of Solid State Lighting Products
NEMA ANSLG C78.380	(2007) Electric Lamps - High Intensity Discharge Lamps, Method of Designation
NEMA ANSLG C78.44	(2008) For Electric Lamps - Double-Ended Metal Halide Lamps
NEMA ANSLG C82.11	(2011) Lamp Ballasts - High-Frequency Fluorescent Lamp Ballasts
NEMA ANSLG C82.14	(2006) Lamp Ballasts Low-Frequency Square Wave Electronic Ballasts -- for Metal Halide Lamps
NEMA C136.10	(2010) American National Standard for Roadway and Area Lighting Equipment-Locking-Type Photocontrol Devices and

	Mating Receptacles--Physical and Electrical Interchangeability and Testing
NEMA C136.20	(2012) American National Standard for Roadway and Area Lighting Equipment - Fiber Reinforced Composite (FRC) Lighting Poles
NEMA C136.31	(2010) American National for Roadway and Area Lighting Equipment - Luminaire Vibration
NEMA C78.LL 3	(2003; R 2015) Electric Lamps - Procedures for High Intensity Discharge Lamp Sample Preparation and the Toxicity Characteristic Leaching Procedure
NEMA C82.77	(2002) Harmonic Emission Limits - Related Power Quality Requirements for Lighting Equipment
NEMA ICS 2	(2000; R 2005; Errata 2008) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2011) Industrial Control and Systems: Enclosures
NEMA IEC 60529	(2004) Degrees of Protection Provided by Enclosures (IP Code)
NEMA WD 7	(2011; R 2016) Occupancy Motion Sensors Standard

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2017) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 1029	(1994; Reprint Dec 2013) High-Intensity-Discharge Lamp Ballasts
UL 1310	(2011; Reprint Dec 2014) UL Standard for Safety Class 2 Power Units
UL 1598	(2008; Reprint Oct 2012) Luminaires

UL 773	(1995; Reprint Jul 2015) Standard for Plug-In, Locking Type Photocontrols for Use with Area Lighting
UL 773A	(2016) Standard for Nonindustrial Photoelectric Switches for Lighting Control
UL 8750	(2015; Reprint Nov 2016) UL Standard for Safety Light Emitting Diode (LED) Equipment for Use in Lighting Products
UL 916	(2007; Reprint Aug 2014) Standard for Energy Management Equipment
UL 935	(2001; Reprint Aug 2014) Standard for Fluorescent-Lamp Ballasts

1.10 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.11 LED LUMINAIRE WARRANTY

Provide Luminaire Useful Life Certificate.

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

a. Provide a written five year on-site replacement warranty for material, fixture finish, and workmanship. On-site replacement includes transportation, removal, and installation of new products.

   1. Finish warranty shall include warranty against failure and against substantial deterioration such as blistering, cracking, peeling, chalking, or fading.

   2. Material warranty shall include:

      (a) All power supply units (drivers).

      (b) Replacement when more than 10 percent of LED sources in any lightbar or subassembly(s) are defective or non-starting.

b. Warranty period must begin on date of beneficial occupancy. Contractor shall provide the

Contracting Officer signed warranty certificates prior to final payment.

1.13 ELECTRONIC BALLAST/DRIVER WARRANTY

Furnish the electronic ballasts/drivers manufacturer's warranty. The warranty period shall not be less than five (5) years from the date of manufacture. Ballast/driver assembly in the lighting fixture, transportation, and on-site storage shall not exceed twelve (12) months, thereby permitting four (4) years of the five (5) year warranty to be in service and energized. The warranty shall state that the malfunctioning ballast/driver shall be exchanged by the manufacturer and promptly shipped to the using Government facility.

The replacement ballast/driver shall be identical to, or an improvement upon, the original design of the malfunctioning ballast.

PART 2 - PRODUCT

2.01 LUMINAIRES

A. Furnish Products as scheduled.

B. Lighting Fixtures: Shall be as shown in the Lighting Fixture Schedule on the Drawings.

2.02 GENERAL REQUIREMENTS

A. Housings for luminaires shall be die cast, extruded, or fabricated aluminum. Fabricated aluminum housings shall have all seams and corners internally welded to resist weathering, moisture and dust.

B. Luminaires shall be rated for operation within an ambient temperature range of minus 30 degrees C minus 22 degrees F to[40 degrees C 104 degrees F][50 degrees C 122 degrees F].

C. Luminaires shall be UL listed for wet locations per UL 1598. Optical compartment for LED luminaires shall be sealed and rated a minimum of IP65 per NEMA IEC 60529.

D. LED luminaires shall produce a minimum efficacy as shown in the following table, tested per IES LM-79. Theoretical models of initial raw LED lumens per watt are not acceptable.

Application	Luminaire Efficacy in Lumens per Watt
Exterior Pole/Arm-Mounted Area and Roadway Luminaires	65
Exterior Pole/Arm-Mounted Decorative Luminaires	65

Exterior Wall-Mounted Area Luminaires	60
Bollards	35
Parking Garage Luminaires	70

E. Luminaires shall have IES distribution and NEMA field angle classifications as indicated in luminaire schedule on project plans per IES HB-10.

F. Housing finish shall be baked-on enamel, anodized, or baked-on powder coat paint. Finish shall be capable of surviving ASTM B117 salt fog environment testing for 2500 hours minimum without blistering or peeling.

G. Luminaires shall be fully assembled and electrically tested prior to shipment from factory.

H. The finish color shall be as indicated in the luminaire schedule or detail on the project plans.

I. Luminaire arm bolts shall be 304 stainless steel or zinc-plated steel.

J. Lenses shall be constructed of clear or frosted tempered glass polycarbonate vandal-resistant lenses as indicated.

K. The wiring compartment on pole-mounted, street and area luminaires must be accessible without the use of hand tools to manipulate small screws, bolts, or hardware.

L. Incorporate modular electrical connections, and construct luminaires to allow replacement of all or any part of the optics, heat sinks, power supply units, ballasts, surge suppressors and other electrical components using only a simple tool, such as a manual or cordless electric screwdriver.

M. Luminaires shall have a nameplate bearing the manufacturer's name, address, model number, date of manufacture, and serial number securely affixed in a conspicuous place. The nameplate of the distributing agent will not be acceptable.

2.03 LUMINAIRE LIGHT SOURCES

2.04 LED LIGHT SOURCES

A. Correlated Color Temperature (CCT) shall be in accordance with NEMA ANSLG C78.377:

1. Nominal CCT: 4000 degrees K: 3985 plus or minus 275 degrees K

B. Color Rendering Index (CRI) shall be:

1. Greater than or equal to [70] [__] for 4000 degrees K light sources.

C. Color Consistency:

1. Manufacturer shall utilize a maximum 4-step MacAdam ellipse binning tolerance for color consistency of LEDs used in luminaires.

2.05 LUMINAIRE DRIVERS

A. LED POWER SUPPLY UNITS (DRIVERS)

B. UL 1310. LED Power Supply Units (Drivers) shall meet the following requirements:

1. Minimum efficiency shall be 85 percent.
2. Drive current to each individual LED shall not exceed 600 mA, plus or minus 10 percent.
3. Shall be rated to operate between ambient temperatures of minus 30 degrees C minus 22 degrees F and 40 degrees C 104 degrees F[50 degrees C 122 degrees F].
4. Shall be designed to operate on the voltage system to which they are connected, typically ranging from 120 V to 480 V nominal.
5. Operating frequency shall be: 50 or 60 Hz.
6. Power Factor (PF) shall be greater than or equal to 0.90.
7. Total Harmonic Distortion (THD) current shall be less than or equal to 20 percent.
8. Shall meet requirements of 47 CFR 15, Class B.
9. Shall be RoHS-compliant.
10. Shall be mounted integral to luminaire. Remote mounting of power supply is not allowed.

11. Power supplies in luminaires mounted under a covered structure, such as a canopy, or where otherwise appropriate shall be UL listed with a sound rating of A.

12. Shall be dimmable, and compatible with a standard dimming control circuit of 0 - 10V or other approved dimming system.

13. Shall be equipped with over-temperature protection circuit that turns light source off until normal operating temperature is achieved.

2.06 LED LUMINAIRE SURGE PROTECTION

A. Provide surge protection integral to luminaire to meet C Low waveforms as defined by IEEE C62.41.2, Scenario 1, Location Category C.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install luminaires as detailed on the drawings or to poles as directed.

3.02 INSTALLATION OF LIGHTING FIXTURES

A. Install all lighting fixtures complete and ready for service, in accordance with the Fixture Schedule on the Drawings:

B. Wire all fixtures with fixture wiring of at least 150 degree C rating.

C. Install all fixtures straight and true with site equipment, sidewalks, etc.

3.03 ADJUSTING

A. Section “Contract Closeout”.

3.04 CLEANING

A. Section “Contract Closeout”: Cleaning installed work.

B. Clean electrical parts to remove conductive and deleterious materials.

C. Remove dirt and debris from enclosures.

D. Clean photometric control surfaces as recommended by manufacturer.

E. Clean finishes and touch up damage.

3.05 DEMONSTRATION AND INSTRUCTIONS

A. Section “Contract Closeout” - Starting of Systems: Demonstrating installed work.

B. Demonstrate luminaire operation for 12 hours.

3.06 PROTECTION OF FINISHED WORK

A. Re-lamp or repair luminaires that have failed at substantial completion.

3.07 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.08 FIELD QUALITY CONTROL

Upon completion of installation, verify that equipment is properly installed, connected, and adjusted. Conduct an operating test after 100 hours of burn-in time to show that the equipment operates in accordance with the requirements of this section.

END OF SECTION

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SECTION 16700

INSTRUMENTS GENERAL

PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The Contractor shall furnish, install, test, and place in operation process instrumentation (flow elements, level transmitters, etc.) as scheduled herein together with all signal converters, transmitters, isolators, amplifiers, etc. to interface with all instrumentation, panels, controls, and process equipment control panels with the process control system as shown on the Drawings and as specified. Mounting of associated transmitters, indicators, power supplies, brackets, and appurtenances shall be provided as specified herein and shown on the Drawings.

B. It is the intent of this Specification and the Contract Documents that all process taps, isolation valves, nipples, penetrations, embedded instrumentation supports, conduit, wiring, terminations, and the installation of the process instrumentation on process lines shall be provided under this Contract.

C. Taps and connections for primary process sensors shall be sized to suit each individual installation and the requirements of the instrument served. It is the Contractor's responsibility to ensure that the location, supports, orientation, and dimensions of the connections and taps for instrumentation as such as to provide the proper bracing, the required accuracy of measurement, protection of the sensor from accidental damage, and accessibility for maintenance while the plant is in operation. Isolation valves shall be provided at all process taps.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Process Control and Instrumentation Systems

B. Division 16.

1.3 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
API RP550	Manual on Installation of Refinery Instruments and Control Systems, Part I – Sections 1 Through 13
ISA S20	Specification Forms for Process Measurement and Control Instrumentation, Primary Elements, and Control Valves
ISA S51.1	Process Instrumentation Terminology

1.4 GENERAL INFORMATION AND DESCRIPTION

A. These Specifications are intended to give a general description of what is required, but do not cover all details which will vary in accordance with the requirements of the equipment furnished.

They are, however, intended to cover the furnishing, the shop testing, the delivery, and complete installation and field testing of all instruments and appurtenances whether specifically mentioned in the Specification or not.

B. The instruments shall be furnished and installed with all necessary accessory equipment and auxiliaries whether specifically mentioned in these Specifications or not. The installations shall incorporate the highest standards for the type of service shown on the Drawings including loop testing of the entire installation and instruction of operating personnel in the care, operation, calibration, and maintenance of all instrumentation.

C. All instrumentation shall be of first class workmanship and shall be entirely designed and suitable for the intended services. All materials used in fabricating the equipment shall be new and undamaged.

PART 2 - PRODUCTS

2.1 GENERAL

A. All instrumentation supplied shall be the manufacturer's latest design. Unless otherwise specified, all instruments shall be solid state, electronic, using enclosures to suit specified environmental conditions. Microprocessor-based equipment shall be supplied unless otherwise specified. All instruments shall be provided with mounting hardware and floor stands, wall brackets, or instrument racks as shown on the Drawings or as required.

B. Equipment installed in hazardous areas shall meet Class, Group, and Division as shown on the Drawings, to comply with the National Electric Code.

C. All instruments shall return to accurate measurement without manual resetting upon restoration of power after a power failure.

D. Unless otherwise shown or specified, local indicators shall be provided for all instruments. Where instruments are located in inaccessible locations, local indicators shall be provided and shall be mounted as specified in paragraph 3.1.B. All indicator readouts shall be linear in process units. Readouts of 0-100% shall not be acceptable, except for speed and valve position. Floating outputs shall be provided for all transmitters.

E. Unless otherwise specified, field instrument and power supply enclosures in corrosive environments shall be 316 stainless steel, fiberglass, or PVC coated copper free cast aluminum NEMA 4X construction.

F. Where separate elements and transmitters are required, they shall be fully matched, and unless otherwise noted, installed adjacent to the sensor. Special cables or equipment shall be supplied by the associated equipment manufacturer.

G. Electronic equipment shall utilize printed circuitry and shall be coated (tropicalized) to prevent contamination by dust, moisture, and fungus. Solid-state components shall be conservatively rated for long term performance and dependability over ambient atmospheric fluctuations. Ambient conditions shall be –15 to 50 degrees C and 10 to 100 percent relative humidity, unless otherwise specified. Field mounted equipment and system components shall be designed for installation in dusty, humid, and corrosive service conditions.

H. All devices furnished hereunder shall be heavy-duty type, designed for continuous industrial service. The system shall contain products of a single manufacturer, insofar as possible, and shall consist of equipment models which are currently in production. All equipment provided, where applicable, shall be of modular construction and shall be capable of field expansion.

I. All non-loop powered instruments and equipment shall be designed to operate on a 60 Hz alternating current power source at a nominal 117 V, plus or minus 10 percent, except where specifically noted. All regulators and power supplies required for compliance with the above shall be provided. Where equipment requires voltage reduction, constant voltage transformers shall be supplied.

J. All analog transmitter and controller outputs shall be isolated, 4-20 milliamps into a load of 0-750 ohms, unless specifically noted otherwise. All switches shall have double-pole, double-throw contacts rated at a minimum of 600 VA, unless specified otherwise.

K. Materials and equipment used shall be U.L. approved wherever such approved equipment and materials is available.

2.2 <u>ACCESSORIES</u>

A. Isolation Valves – Valves shall be full port ball valves with ASTM A276, Type 316 stainless steel trim and body and with Teflon seats and packing. Valves shall be Parker CPI, Whitey, Hoke, or equal.

B. Gage Valves – Gage valves shall be machined from ASTM A276 bar stock and shall be provided with 1/2-inch NPT connections and integral bleed valve. Valves shall be Anderson, Greenwood & Company M9530, Hoke 6801L8Y, or equal.

C. Root Valves – Root valves shall be ASTM A276, Type 316 stainless steel bar stock with 1/2-inch NPT male process connection and three 1/2-inch NPT female instrument connections. One instrument connection shall be provided with an ASTM A276, Type 316 stainless steel bleed valve. ASTM A276, Type 316 stainless steel plugs shall be provided for unused ports. Lagging type units shall be provided for insulated vessels and pipes. Root valves shall be Anderson, Greenwood & Company M5 AVS-44, Hoke 6802L8Y, or equal.

D. Manifolds – Manifolds shall be three-valve bar-stock type. Manifold body shall be machined from 316 stainless steel bar stock. Valves shall be globe configuration with 316 stainless steel ball seats and Teflon stem packing. Manifolds shall be designed for direct mounting to differential pressure transmitters in place of the flanges normally furnished. Fabricated manifolds or manifolds employing needle or soft seat valves are not acceptable. Purge taps, 1/8-inch NPT shall be furnished on manifolds where water purge is specified. Manifolds shall be Anderson Greenwood M4TVS, Hoke 8123F8Y, or equal.

E. Tubing – Instrument tubing between the process connection and instruments shall be 1/2-inch x 0.065-inch seamless annealed ASTM A269, Type 316 stainless steel. Tubing fittings shall be Type 316 stainless steel. Fittings shall be of the swage ferrule design and shall have components (nut, body and ferrule system) interchangeable with those of at least one other manufacturer. Flare and ball sleeve compression type are not acceptable. Fittings shall be Parker CPI, Crawford Swagelok, Hoke Gyrolok, or equal.

F. Chemical Seals

1. Diaphragm – Seal shall be the diaphragm type with flushing connection, Type 316 stainless steel body and Type 316L diaphragm unless otherwise specified. Seal shall be Mansfield and Green Type SG, Ashcroft Type 101, or equal.

2. Annular Ring – Seal shall be the in-line full stream captive sensing liquid type. Metallic wetted parts shall be Type 316 stainless steel. Flexible cylinder shall be Buna-N unless otherwise specified. Seals shall be rated 200 psig with not more than 5-inch WC hysteresis. Seals shall be Ronningen-Petter Iso-Ring, Red Valve series 40, or equal.

3. Fill Fluid – Chemical seals and associated instruments shall be factory filled as follows: Instrument side of seal, capillary tubing, and instrument shall be evacuated to an absolute pressure of 1.0 Torr or less; filled; and sealed. Unless otherwise specified, fill fluid shall be silicone oil, Dow Corning DC200, Syltherm 800, or equal.

G. Bushings and Thermowells – Bushings or thermowells shall comply with SAMA PMC17-10. Temperature taps shall be 1/2-inch NPT, and lagging extensions shall be provided on insulated vessels or pipes. Thermowells and bushings shall be machined from Type 316 stainless steel bar stock unless otherwise specified.

H. Purge Assemblies

1. Air – Air purge assembly shall consist of a constant-differential relay, needle valve, check valve and 0.2 to 2.0 scfh rotameter. Assembly shall be Moore Products 62VA, Fischer & Porter 10A3137N-3BR2110, or equal.

2. Water – Water purge assembly shall consist of a strainer, constant-differential regulator, needle valve, check valve, and 20 to 200 cc/m rotameter. Assembly shall be Moore Products 63BD4A, Fischer & Porter 10A3137N-53BR2110, or equal. Strainer shall be 155 micron wye-type, ASCO 8600A2, Crane, or equal.

2.3 POWERED INSTRUMENTS GENERAL REQUIREMENTS

A. Powered instruments are those instruments which require power (120 VAC or 24 VDC loop power) to operate. Each instrument includes an element or analyzer and a transmitter/controller.

B. Transmitters shall be 4 to 20 milliampere output two-wire type with operating power derived from the transmission circuit. Transmitter shall support an external load of 0 to 600 ohms or greater without requiring trimming resistors with a transmission circuit power supply of 24 volts. Transmitter output shall be galvanically isolated from the process and the transmitter case. Time constant of transmitters used for flow or pressure measurement, including level transmitters used for flow measurement, shall be adjustable from 0.5 to 5.0 seconds. Transmitter output shall increase with increasing measurement except where "reverse action" is specified in the instrument schedule.

C. Electrical parts of transmitter and/or primary element mechanisms shall, as a minimum be housed in enclosures meeting NEMA 250, Type 4 requirements. Where electrical mechanisms are located outdoors or in areas specified as corrosive, enclosures shall meet NEMA 250, Type 4X requirements.

D. Transmitters located outdoors shall be provided with surge protectors: Rosemount Model 470A, Taylor 1020FP, or equal.

E. Where two-wire transmitter is located in an area classified as hazardous, it shall be made safe by means of an intrinsic safety barrier. Intrinsic safety barriers for two-wire transmitters shall be of the active, isolating, loop powered type. Barrier shall be Measurement Technology LTD. type MT3042, Stahl 9005/01-252/100/00, or equal.

F. Where four-wire transmitters are permitted, they shall be provided with a loop powered signal current isolator connected in the output signal circuit. Isolator shall provide galvanic isolation of milliampere transmission signals from transmitters with inadequately isolated output circuits. Isolator shall be housed in a NEMA 250, type 4/7 conduit body and shall derive its operating power from the signal input circuit. Input and output signals shall be 4 to 20 milliamperes, and error shall not exceed 0.1 percent of span. Input resistance shall not exceed 550 ohms with an output load of 250 ohms. Isolator shall be Moore Industries SCX/4-20MA/ 4-20/MA/6.5DC/-RF(EX).

2.4 PROCESS SWITCHES GENERAL REQUIREMENTS

A. Contact outputs used for alarm actuation shall be ordinarily closed and shall open to initiate the alarm. Contact outputs used to control equipment shall be ordinarily open and shall close to start the equipment. Contacts monitored by solid state equipment such as programmable controllers or annunciators shall be hermetically sealed and designed for switching currents from 20 to 100 mA at 24 volts DC. Contacts monitored by electromagnetic devices such as mechanical relays shall be rated NEMA ICS 2, designation B300. Double barriers shall be provided between switch elements and process fluids such that failure of one barrier will not permit process fluids into electrical enclosures. Switch electrical enclosures shall be rated NEMA 250, type 4 minimum. Contacts in Class 1, Division 1 areas and monitored by solid-state circuits shall be made safe by suitable intrinsic safety barriers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General – Equipment shall be located so that it is accessible for operation and maintenance. Electrical work shall be performed in compliance with all applicable local codes and practices. Where these specifications and the Drawings do not delineate precise installation procedures, API RP550 shall be used as a guide to installation procedures.

B. Equipment Mounting and Support

1. Field equipment shall be wall mounted or mounted on two-inch diameter aluminum pipe stands welded to a 10-inch square, ½-inch thick aluminum steel baseplate. Instruments attached directly to concrete shall be spaced out from the mounting surface not less than ½-inch by use of phenolic spacers. Expansion shields in walls shall be used for securing equipment or wall supports to concrete surfaces. Unless otherwise noted, field instruments shall be mounted between 48 and 60 inches above the floor or work platform.

2. Embedded pipe supports and sleeves shall be schedule 40, 304 stainless steel pipe, with stainless steel blind flange for equipment mounting as shown on the Drawings.

3. Materials for miscellaneous mounting brackets and supports shall be 304 stainless steel.

4. Pipe stands, mounting brackets, and supports shall comply with the requirements of Division 5.

5. Where transmitters are supported from process piping, leveling saddles shall be provided. Transmitters shall be oriented such that output indicators are readily visible.

C. Control and Signal Wiring – Electrical, control, and signal wiring connections to transmitters and elements mounted on process piping or equipment shall be made through liquid-tight flexible conduit. Conduit seals shall be provided where conduits pass from classified to unclassified areas.

3.2 CLEANING AND ADJUSTMENT

A. General

1. The Contractor shall comply with the requirements of Division 1 and all instrumentation and control system tests, inspection, and calibration requirements for all instrumentation and controls provided under this Contract and specified herein. The Engineer, or his designated representative(s), reserve the right to witness any test, inspection, calibration, or start-up activity. Acceptance by the Engineer of any plan, report, or documentation relating to any testing or commissioning activity specified herein shall not relieve the Contractor of his responsibility for meeting all specified requirements.

. The Contractor shall provide the services of factory trained technicians, tools, and equipment to field calibrate, test, inspect, and adjust each instrument to its specified performance requirement in accordance with manufacturer's specifications and instructions. Any instrument which fails to meet any contract requirements, or any published manufacturer performance specification for functional and operational parameters, shall be repaired or replaced, at the discretion of the Engineer, at no cost to the Owner. The Contractor shall bear all costs and provided all personnel, equipment, and materials necessary to implement all installation tests and inspection activities for equipment specified herein.

B. Field Instrument Calibration Requirements

1. Each instrument shall be calibrated at 0, 25, 50, 75, and 100 percent of span using test instruments to simulate inputs and read outputs. Test instruments shall be rated to an accuracy of at least five times greater than the specified accuracy of the instrument being calibrated. Where applicable, such test instruments shall have accuracies as set forth by the National Bureau of Standards.

2. The Contractor shall provide a written calibration sheet to the Engineer for each instrument, certifying that it has been calibrated to its published specified accuracy. This sheet shall include but not be limited to date, instrument tag numbers, calibration data for the various procedures, name of person performing the calibration, listing of published specified accuracy, permissible tolerance at each point of calibration, calibration reading as finally adjusted within tolerance, defect noted, corrective action required, and corrections made.

3. If doubt exists as to the correct method for calibrating or checking calibration of an instrument, the manufacturer's recommendations shall be used as an acceptable standard, subject to approval of the Engineer.

4. Upon completion of calibration, devices calibrated hereunder shall not be subjected to sudden movements, accelerations, or shocks, and shall be installed in permanent protected positions not subject to moisture, dirt, and excessive temperature variations. Caution shall be exercised to prevent such devices being subjected to overvoltages, incorrect voltages, overpressures, or incorrect air. Damaged equipment shall be replaced and recalibrated at no cost to the Owner.

5. Upon completion of instrumentation installation, the Contractor shall perform a loop check. The Contractor shall submit final loop test results with all instruments listed in the loop. Loop test results shall be signed by all representatives involved for each loop test.

END OF SECTION

SECTION 16706
PLC PROGRAMMING SOFTWARE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. General requirements for application software to be used in conjunction with the specified PLC hardware.

B. General:

1. The control system logic program shall reside at the PLC level. Software shall be provided and by installed and programmable by the Programming Contractor.

C. Related Sections:

1. Contract documents are a single integrated document, and as such all Division and Sections apply. It is the responsibility of the Contractor and its Sub-Contractors to review all Sections to ensure al complete and coordinated project.

1.2 SUBMITTALS

A. Furnish complete product data, operating manuals, manufacturer's certifications, and other submittals as described.

B. Additional Requirements:

1. Product Data:
    a. Programming languages.
    b. Operating system requirements.
2. Control logic:
    a. Fully annotated copy of programmed PLC logic.
    b. Cross-referenced index of all PLC registers or points.

1.3 QUALITY ASSURANCE

A. System Compatibility.

1. The software must be the standard operating software system designed specifically for use with the PLC hardware.
2. The software must be furnished and developed by the manufacturer of the PLC hardware.

1.4 WARRANTY

A. Provide extended 2 year manufacturer's warranty support as follows:

1. Dedicated technical support department or handled by programming staff or distributor.
2. Telephone hours for support shall be 24 hours, 7 days per week.
3. Email and web support addresses.
4. Document download via website.
5. Field services.

1.5 MAINTENANCE

A. Provide system upgrades and maintenance fixes for a period of two years from substation completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Programming Software: The following, not equal:
   1. As needed to program Modicon M340 PLC and selected compatible OIT.

2.2 MANUFACTURED UNIT

A. PLC Programming Software:
   1. The PLC based control system software package shall be able to monitor and/or control PLC's via the PLC data network.
      a. It shall contain diagnostics to collect troubleshooting and performance data and display it in easy to understand graphs and tables.
      b. It shall also monitor devices at each drop on the PLC data network for proper communications.
      c. It shall provide the ability to program all PLC on the PLC data network from the Engineer's Console.
   2. All PLC programming shall be accomplished using a standard software package developed for this purpose.
   3. The software package shall be installed on the hard disk of the portable PLC programming terminal, as well as the Engineers Console, EC.
   4. Operating System
      a. Microsoft Windows XP.
   5. The PLC programming software shall be suitable for the PLCs furnished under Section 17720.
   6. All programming, monitoring, searching, and editing shall be accomplished using this PLC programming software.
      a. It shall be usable both online, while connected to the PLC, and offline .

b. The PLC programming software shall display multiple series and parallel contacts, coils, timers, counters, and mathematical functions blocks.

c. The software shall be able to monitor the status of all inputs, outputs, timers, counters and coils.

d. It shall have the capability to disable/force all inputs, outputs and coils to simulate the elements of the ladder logic by means of color change.

e. It shall include a search capability to locate any address or element and its program location.

f. PLC status information, such as error indication and amount of memory remaining shall be shown on the CRT screen.

7. The PLC programming software shall support the following programming languages:

   a. Ladder diagram

   b. Function block diagram

   c. Structured text

   d. Sequential function chart

8. The PLC programming software shall have the capability to generate a PLC program printout, which is fully documented.

   a. Fully documented program listings shall have appropriate rungs, address, and coils shown with comments to clarify to a reader what the segment of the program accomplishes.

   b. There shall be a comment for each and every rung of the program explaining the control function accomplished in said rung.

   c. Each contact, coil, etc shall have a mnemonic associated with it that describes its function

   d. The Tag and Loop identification as contained in the P&IDs shall be used whenever possible. Identify each input and output with a name consistent and identifiable with the corresponding equipment.

      1) If additional internal coils, timers, etc are used for a loop they shall contain the loop number.

   e. A fully documented listing shall also include a cross-reference report of program addresses.

9. Operating system software shall function automatically without operator intervention, except as required to establish file names and similar information.

   a. The real-time operating system software shall be the standard uncorrupted product of the PLC manufacturer and shall provide the following minimum functions:

      1) Respond to demands from a program request.

2) Dynamic allocation of the resources available in the PLC. These resources shall include main memory usage, computation time, peripheral usage, and I/O channel usage.

3) Allotment of system resources on the basis of task priority levels such that a logical allocation of resources and suitable response times are assured.

4) Queuing of request in order of priority if one or more requested resources are unavailable.

5) Resolution of contending requests for the same resources in accordance with priority.

6) Service requests for execution of one program by another.

7) Transfer data between programs as requested.

8) Management of all information transfers to and from peripheral devices.

9) Control and recovery from all program fault condition.

10) Diagnose and report real-time hardware device errors.

10. Program Execution:

a. Program execution shall be scheduled on a priority basis.

1) A multilevel priority interrupt structure is required.

2) A program interrupted by a higher priority program shall be entered into a list of pending programs.

3) Its execution shall be resumed once it becomes the currently highest priority program.

4) The system shall allow periodic programs to be scheduled.

5) The allocation of resources to a time-scheduled program shall be based on its relative priority and the availability of resources.

6) Initiation of programs shall, as a minimum, be activated in the following ways:

a) In response to external interrupts.

b) At a scheduled time of the day.

c) On an elapsed time interval basis.

d) On request by another program

11. Start-up and Restart:

a. Software shall be provided which initializes and brings a PLC or any microprocessor based hardware unit from an inactive condition to a state of operational readiness.

b. Initialization shall include determination of system status prior to start -up of initializing operating system software and initializing application software.

c. Initialization shall also include the loading of all memory-resident software, initializing timers, counters, and queues, and initialization of all dynamic database values.

12. Shutdown:
    a. The software shall provide an orderly shutdown capability for shutdowns resulting from equipment failure, including PLC processor failure, primary power failure, or a manually entered shutdown command.
    b. When the loss of primary power is sensed, a high -priority hardware interrupt shall initiate software for an immediate, orderly shutdown.
    c. When a shutdown occurs in response to a command or malfunction, the software shall control the affected hardware quickly and automatically to a secure state.
    d. The failure of the PLC shall be detected at the operator interface level.
13. Diagnostics:
    a. Diagnostic programs shall be furnished with the PLC software package to detect and isolate hardware problems and assist maintenance personnel in discovering the causes for system failures.
    b. The manufacturer's standard diagnostic routines shall be used as much as possible.
    c. Diagnostic software and test programs shall be furnished for each significant component in the control system.
    d. Diagnostic routines shall test for power supply, central processing unit, memory, communications and I/O bus failures as a minimum.
14. Calendar/Time Program:
    a. The calendar/time program shall update the second, minute, hour, day, month, and year in the operating system and transfer accurate time and date information to all system level and application software.
    b. Variations in the number of days in each month and in leap years shall be handled automatically by the program.
    c. The operator shall be able to set or correct the time and date from any operator interface, only at the highest security level.
    d. The calendar/time program shall be year 2000 compliant.
15. Algorithms:
    a. PLC software shall support the implementation of algorithms for the determinations of control actions and special calculations involving analog and discrete data.
    b. Algorithms shall be capable of outputting positional or incremental control outputs or providing the product of calculations.
    c. Algorithms shall include alarm checks where appropriate.

       As a minimum, the following types of algorithms shall be provided:

       1) A calculator algorithm, which performs functions such as summing several variables, raising to a power, roots, dividing, multiplying, and subtracting.

2) A switch algorithm, which reads the current, value from its input address and stores it as the value of its output address. Two types of switches shall be accommodated, two outputs with one input and one output with two inputs.

3) A three -mode Proportional -Integral -Derivative, PID, controller

4) algorithm, with each of the three modes independently adjustable.

5) The algorithm shall support both direct and reverse acting modes.

6) Algorithms for lead, lag, dead time, and ratio compensators.

7) Algorithms to perform integration and totalization of analog process

8) variables.

d. All flow rates and run status inputs shall be totalized within the PLC/RTU registers.

B. Analog Database:

1. A comprehensive database shall be furnished for the analog inputs, calculated values, control modules, and outputs.

   a. In addition, spare database points shall be provided for future expansion.

2. One integrated database can be utilized for all types of analog points or separate databases for each type, in either case the database for each point shall include all specified aspects.

3. All portions of the database shall be available for use by the display, report, and other specified software modules.

4. All of the data fields and functions specified below shall be part of the point definition database at the operator interface. It shall be possible to define new database points through the point display specified below as well as modifying defined points through these displays. This point definition and modification shall include all of the features and functions defined below. The analog database software shall support the following functions and attributes.

   a. Analog Input Signal Types:

      1) Software shall be provided at the RTUs and PLCs to read variable voltage/current signals and pulse duration/frequency type analog input signals.

   b. Input Accuracy:

      1) Inputs shall be read with an accuracy of ±0.05 percent full scale or better.

      2) No data conversion errors shall exceed ±0.05 percent full scale.

      3) Pulse accumulation error shall not exceed :tone (1) count of actual input count at a scan rate of once a minute.

      4) The system accuracy stated above shall be maintained for a period of at least one year without adjustments.

   c. Validity Checking:

1) All analog inputs shall be checked to determine whether they are within a valid measurement range as determined by the zero and span limits of the input.

2) If a signal is outside of its valid range, a flag shall be set to indicate an over/under range condition and the signal shall be clamped at its minimum or maximum value, as appropriate.

3) The validity checking shall allow for up to 2 percent zero drift and automatically damp the signal at its maximum/minimum value if it is within this two percent range, adjustable, without setting the invalid signal flag.

4) It shall be possible to clamp a signal to its zero value based on an external event, ie. drive a pump flow signal to zero when the pump is off.

d. Blocking:

1) It shall be possible to inhibit or block the scanning and/or processing of any analog input through the operator interface.

2) For any input so blocked, it shall be possible for the operator to manually enter a value to be used as the input value.

e. Filtering:

1) Each analog input shall be provided with a first order lag digital filter with an adjustable filter factor.

f. Linearizing:

1) Where analog inputs require square root extraction or other linearization, means shall be provided to condition the filtered data before the process of scaling and zero suppression take place.

g. Calculated Values:

1) Means shall be provided to allow for pseudo-inputs calculated by algebraic and/or Boolean expressions utilizing real inputs, other calculated value, constants, etc.

2) These values shall be handled the same as real inputs in terms of record keeping, alarming, etc.

h. Scaling and Zero Suppression:

1) A conversion program shall be provided to convert input values into engineering units in a floating point format.

2) Alarms:

3) An alarm program shall be provided to check all analog variables against high-high, high, low, and low-low alarm limits.

4) When an analog value exceeds a set limit, it shall be reported as an

5) alarm based on individually set priority level for each alarm point

6) There shall be an adjustable hysteresis band in order to prevent

7) excessive alarms when a variable is hovering around an alarm limit.

8) Return to normal shall also be reported.

9) It shall be possible to inhibit alarms based on external events, ie. lock-out low pump flow alarm when the pump is off.

i. Averages:

1) There shall be provided a program to calculate and store hourly, daily, and monthly averages of analog variables.

2) Averages shall be continuously computed, ie. the average for the current period to the present point in time shall be stored in memory and available for use in displays, etc.

3) Hourly averages shall be updated each minute or at the polling interval for the selected variable.

4) Daily averages shall be updated at least once each hour and shall be calculated using the results of the hourly averages.

5) Monthly averages shall be updated at least once each day and shall be calculated using the results of the daily averages.

6) At the end of each averaging period, the average values for the period shall be stored on the hard disk for historical record keeping and the present period average register shall be reset to the present value of the variable.

7) The active database shall include the present period average and previous period average for each variable and averaging period.

j. Totals:

1) There shall be provided a program to calculate and store hourly, daily, and monthly totalization of analog variables.

2) There shall be a scaling factor assignable to each variable to convert

3) to the appropriate units based on a one-minute totalizing interval.

4) A separate factor shall be assignable for each totalizing interval.

5) Variables for which totalization is inappropriate shall have scaling

6) factors of zero.

7) At the end of each totalizing period, the totalized values for the period shall be stored on the hard disk for historical record keeping and the present period totalization register shall be reset to zero.

8) 6) The active database shall include the present period total and previous period

k. Totals

1) There shall be provided a program to determine and store the maximum and minimum values of analog variables and their time of occurrence during the hour, the day, and the month.

2) At the end of each period, the maximum and minimum values for the period shall be stored on the hard disk for historical record keeping and the present period maximum and minimum registers shall be reset to the present value of the variables.

3) The active database shall include the present period maximum and minimum values and the previous period maximum and minimum values for each variable and period.

l. Engineering Units:

1) Software shall be provided to allow the system and the operator to convert all the measured analog variables to any desired engineering units.

2) The operator shall be able to view displays and generate reports of any measured variable in one or more engineering units such as flow in GPM, MGD, CFS and Acre-Feet per day.

3) The conversion of the engineering units shall be preprogrammed, and if not pre-programmed, the operator shall be able to program new engineering unit conversions by using simple methods, ie. multiplication of the database attributes by a constant.

4) The programming method shall be at a level and compatible with the specified training of the operator and the OWNER'S personnel.

5) New conversions shall not require the services of a special programmer and/or special, high-level, programming training.

m. Control Modules:

1) For each control function configured, whether processed at the RTU, PLC, or operator interface, there shall be maintained a file of necessary data including input values, setpoints, constants, intermediate calculated values, output value and limit clamps, etc.

2) Input and output assignments, setpoints, and constants shall be adjustable by the operator through the operator interface.

3) Control algorithms shall provide for manual control and output values shall be adjustable by the operator.

n. Analog Outputs:

1) Analog outputs shall be maintained as part of the database.

2) These outputs shall be adjustable manually by the operator through the operator interface or through automatic control algorithms.

5. Some of the above functions may be better accomplished in the Data Acquisition and Graphic Display Software package, it is the responsibility of the ICSC to optimize the location of the various functions between all software packages.

C. Digital Database:

1. A comprehensive database shall be furnished for the digital inputs, calculated points, control logic, and outputs.

   a. In addition, spare database points shall be provided for future expansion to match the spare I/Os.

2. One integrated database can be utilized for all types of digital points or separate databases for each type, in either case the database for each point shall include all specified aspects.
3. All portions of the database shall be available for use by the display, report, and other specified software modules.
4. All of the data fields and functions specified below shall be part of the point definition database at the operator interface.
   a. It shall be possible to define new database points through the point display specified below as well as modifying defined points through these displays. This point definition and modification shall include all of the features and functions defined below. A copy of those portions of the database that are necessary for execution at the RTU and/or PLC shall be maintained at the RTU and/or PLC. The digital database software shall support the following functions and attributes.
      1) Digital Input Signal Types:
         a) Software shall be provided to allow for single, two state, and dual, three state, inputs.
      2) Noise Rejection:
         a) Input bounce filter shall be provided through software if not furnished with input hardware.
      3) Blocking:
         a) It shall be possible to inhibit or block the scanning and/or processing of any digital input through the operator interface.
         b) For any input so blocked, it shall be possible for the operator to set the state of the input.
      4) Calculated Points:
         a) Means shall be provided to allow for pseudo-inputs calculated from boolean expressions.
      5) Status and Alarm:
         a) Each digital point shall be assigned a priority level for change of state reporting as an alarm.
      6) Totals:
         a) There shall be provided a program to calculate and store daily and monthly run time, in hours and tenths, and number of start totals of digital inputs.
         b) At the end of each totalizing period, the totalized values for the period shall be stored on the hard disk for historical record keeping and the present period totalization register shall be reset to zero.

c) The active database shall include the present period totals and the previous period totals for each input and totalizing period.

d) There shall also be provided a non-resetting, lifetime, run time and number of start totalizer provided for each input.

7) Digital Outputs:

a) Digital outputs shall be maintained as part of the database.

b) Software shall be provided to allow for single, two state, and dual, three state, output types.

c) Output change of state shall be reported as described for inputs.

d) It shall be possible for outputs to be set manually by the operator through the operator interface or automatically through control logic and sequences.

5. Some of the above functions may be better accomplished in the Data Acquisition and Graphic Display Software package, it is the responsibility of the ICSC to optimize the location of the various functions between all software packages.

D. General Control Functions

1. 1.Analog Control Functions:

a. PID, lead/lag, signal select, alarm, limit, delay, and time base.

b. The control system shall be furnished complete with a library of mathematical/calculation software to support averaging, weighted average, addition, subtraction, multiplication, division, square root extraction, exponential, AND, OR, NAND, NOR, XOR and NXOR functions.

c. All math utilities shall be linkable to process data points or manual inputs via control block configuration.

d. By linking control blocks to data points, the math library shall support system unit conversion and calculation requirements.

2. Discrete Control Functions:

a. AND, OR, NOT, EXCLUSIVE OR, comparators, delays and time base.

3. Software Support:

a. All control and logic functions shall be retained in firmware at each RTU and PLC and in RAM at the operator interface.

b. Each function shall be called as required by the configured controls to perform the intended function.

4. Control and Status Discrepancies:

a. A discrepancy/fail alarm shall be generated for any pump, valve, or final control element if a discrepancy exists between a system or operator command and the device status.

b. For example, the system commands to start (call), and the pump fails to start (run status report back), within predetermined operator programmable time delay (time disagree), then a discrepancy (fail) alarm shall be generated.

c. Involuntary change in the device's status shall also generate an alarm.

1) For example, a pump starts when not commanded to do so, or a pump shuts down while running even though it still has a command to run.

d. Each command, status and alarm shall cause the color of the symbol to change.

e. Because many discrete final control elements have a cycle time in excess of the scan interval, each control output shall have an associated delay period selected to be longer than the operating period of the control element.

1) Delay periods for each final control element shall be adjustable at the operator interface.

2) All time delays shall be listed in the final documentation.

5. Some of the above functions may be better accomplished in the Data Acquisition and Graphic Display Software package, it is the responsibility of the ICSC to optimize the location of the various functions between all software packages.

E. Control Configuration:

1. Software shall be provided to allow control strategies to be developed and their operation initiated through the operator interface.

2. Standardized control point displays shall allow for defining the control functions including the function type, input/output addresses, set points and tuning constants, etc.

3. In a similar manner, it shall be possible to link separate control functions together into an integrated control strategy.

4. It shall be possible to download operational/control set points developed at any operator interface to any PLC or RTU for operational implementation.

5. It shall also be possible to define and implement operational/control set points locally at the PLC or RTU and to upload them to the Operator interface for operational record keeping.

6. Control configurations shall be performed on-line at the operator interface, but the PLC or RTU may be taken off-line when being configured or downloaded.

2.3 SOURCE QUALITY CONTROL

PART 3 - EXECUTION

3.1 EXAMINATION

3.2 INSTALLATION

A. All tags used and/or assigned as part of the application programming work provided by the Programming Contractor shall use the Tag and Loop identifications found on the P&IDs.

3.3 TRAINING

A. The training shall be performed by pre-approved and qualified representatives of the Programming Contractor and or manufacturer of the local operator interface software. A representative of the Programming Contractor may perform the training only if the representative has completed the manufacturer's training course for the PLC programming software.

END OF SECTION

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SECTION 16707- CONTROL SYSTEMS
NETWORK EQUIPMENT

PART 1 - GENERAL

1.1 SCOPE

A. Sections Includes

1. Materials and equipment used in process control and LAN networks including:

a. Network switches.

b. Other data network hardware.

B. Furnish a complete operating data network as indicated on the Drawings, as shown on the cable or system block diagrams; and as specified herein.

C. The process control LAN and the business office LAN shall be separate networks as shown on the Drawings. Some equipment required for the business office LAN shall be provided by the Owner at a future date.

D. Related Sections: The Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the Contractor and its Sub-Contractors to review all sections to ensure a complete and coordinated project.

1.2 REFERENCES

A. TIA/EIA Standards:

1. TIA/EIA-568-B (Series), Commercial Building Telecommunications Standards.

2. TIA/EIA-569 (Series), “Commercial Building Standard for Telecommunications Pathways and Spaces”

3. IEEE Series 802 standards.

1.3 DEFINITIONS

1.4 SUBMITTALS

A. Furnish complete Product Data, Shop Drawings, Test Reports, Operating Manuals, Record Drawings, Manufacturer’s certifications, Manufacturer’s Field Reports, and other submittals as specified.

B. Additional Requirements

1. Product Data:

a. Complete Manufacturer’s brochures for each item of equipment. Mark up to clearly show options and components to be provided, and cross out any options or components that will not be provided.

b. Include information on all test equipment.

c. Manufacturer's operation and installation instructions.

2. Shop Drawings:

a. Complete set of drawings including but not limited to:

1) System block diagram showing relationship and connections between devices provided under this Contract. Include manufacturer and model information, and address settings.

2) Network riser diagram.

3) Network port diagram, which physically locates all ports, within the facility, and identifies their patch panel and switch port.

4) Construction drawings for all equipment cabinets, including dimensions, identification of all components, preparation and finish data, nameplates.

5) Electrical connection diagrams.

6) Complete grounding requirements.

3. Test Reports

a. As noted herein.

b. Signed test results as described in Part 3 of this Section.

c. Test results shall include:

1) Narrative describing the test procedures followed.

2) Block diagram of test set up.

3) Manufacturer's information on test equipment used.

4) Detailed test results.

5) A narrative summarizing the results of the testing and identifying any further action required.

1.5 DELIVERY, STORAGE AND HANDLING

A. Store all network equipment in a dedicated structure with space conditioning to meet the recommended storage requirements provided by the manufacturer:

1. Replace any network equipment components that are not stored in strict conformance with the manufacturer's recommendation.

1.6 PROJECT OR SITE CONDITIONS

A. Network equipment shall be suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, ambient temperature, and humidity conditions.

1.7 WARRANTY

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Ethernet Switches: - Office Network -

1. Managed Enterprise Ethernet Switches:

   a. Manufacturers – One of the following:

      1) The part number shall match those existing in the treatment plant, or approved by OWNER.

2. Performance:

   a. Latency: Less than 10.2 microsecond.

   b. Switch fabric speed: 18.3 Gbps, minimum.

   c. Address Table Size: 8,000 entries, minimum.

   d. Gigabit throughput.

3. Environment:

   a. Operating Temperature Range: 32 to 131 Deg Fahrenheit.

   b. Humidity: 15 to 95 percent, non-condensing.

4. Capable of performing basic switching without special programming or configurations. Additional features available through software setup includes but not limited to:

   a. Port Monitoring.

   b. Remote switch management.

   c. Port Security.

   d. Switch Meshing.

   e. Rapid Spanning Tree protocol.

5. Capable of adding or swapping modules without interrupting the network.

6. Modules:

   a. 10/100 Base-TX:

      1) Protocl: IEEE 802.3 Type 10Base_T; 802.3u Type 100base-TX.

      2) Auto-sensing

      3) Connector: RJ-45 – CAT 6.

      4) 24 ports per module.

   b. Fiber optic 100-Base-FX.

      1) Protocl: IEEE 802.3u 100Base-FX.

      2) Full Duplex

      3) Metallic MT-RJ type connectors for use with 62.5 micron multimode optical fiber.

4) 6 ports per module

c. 100/100-Base-T:

1) Protocol: IEEE 802.3u Type 100Base; 802.3ab Type 1000Base-T.

2) Auto-sensing.

3) Connector: RJ-45 CAT 6.

4) 1 port per module.

d. Fiber Gigabit-SX:

1) Protocol: IEEE 802.3z Type 1000Base-SX.

2) Full duplex.

3) Metallic SC-type connectors for use with 62.5 micron multimode optical fiber.

e. Provide modules required to provide network connections as indicated on the Drawings.

1) As required to provide the number of connections required plus 20 percent spare ports of each type used.

7. Spare Parts:

a. Provide the following spare components:

1) One spare module of each type provided.

2) One spare Ethernet switch backplane.

3) One spare Ethernet switch power supply.

B. Ethernet Switches: - SCADA Network -

1. Process Floor Ethernet Switches:

a. Manufacturers – One of the following:

1) N-Tron 7014FX2.

2) Cisco 2950 Series.

3) No Equal.

b. Properties:

1) Hardware

a) Power Supply

(1) Provide redundant power supplies.

(2) 24VDC, 350 Watts/per power supply.

2) Performance

a) Switch fabrix speed: 8 GBPS, minimum

3) Environment:

a) Operating Temperature Range: 32 to 131 Degrees Fahrenheit.

b) Humidity: 15 to 95 percent, non-condensing.

4) Capable of performing basic switching without special programming or configurations. Additional features available through software setup includes but not limited to:

a) Remote switch management.

b) Port security

c) Rapid spanning tree protocol.

5) Metallic SC-type connectors for use with 62.5 micron multimode optical fiber.

a) Provide modules required to provide network connections as indicated on the Drawings.

(1) As required to provide the number of connections required plus 20 percent spare ports of each type used.

6) RJ45 connectors for use with Cat 5e or Cat 6 cable.

7) Mounting:

a) DIN Rail.

2. Power Over Ethernet (POE)

a. Manufactures

1) The part number shall match those existing in the treatment plant, or approved by OWNER.

2) Phoenix Contact.

b. Properties:

1) Four pair of two RJ45 10/100BaseTX copper ports.

a) One RJ45 connects to an existing network.

b) Other RJ45 in the pair can send data and up to 15.4 Watts of power.

2) The data on all four pairs are isolated from each other.

3) Redundant power inputs.

4) 2 million hour MTBF.

5) -40ºC to 85ºC operating temperature range.

6) ESD protection.

7) RFI immunity.

8) POE Network devices shall be sized with the count of ports and wattage overall and of each port necessary for all end devices.

C. Fiber Optic Panel

1. LIU – Light Interface Unit.

a. Manufactures:

1) The part number shall match those existing in the treatment plant, or approved by OWNER.

b. Properties:

1) 2 CCH panels minimum.

2) 24 fiber capacity minimum.

3) Corning PWH-02P

2.2 ACCESSORIES

A. Provide duplex patch cords to connect the interface cards provided with the associated patch panels.

B. Uninterruptable Power Supply (UPS)

1. Provide one UPS for each networking enclosure.

2. UPS shall power all components in networking enclosure and all workstations and servers.

3. As shown on the Drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Upon delivery to the site, examine all cables and components for damage.

3.2 INSTALLATION

A. All racks shall be level and plumb.

B. Install Velcro wrap on all cable bundles within the network/enclosure.

C. All cables and equipment shall be installed in strict conformance with the manufacturer's recommendations.

1. Cables shall be installed avoiding sharp bends.

2. Install cable using lubricant designed for cable pulling.

3. Cable ties or other cable supports shall be installed without crimping the LAN cables.

4. Install LAN cables without splices.

5. Installed bend radii shall not exceed 4 times the cable diameter.

6. Terminate all pairs at the jack and the patch panel.

D. Install cables a minimum of 40 inches away from electrical motors and transformers.

E. Install cables a minimum of 12 inches away from fluorescent lighting.

F. Individual pairs will be untwisted less than 0.5" at termination points.

G. All cables and terminations shall be labeled with cable designations as described in the Division 16 specifications.

H. Each data port shall be individually labeled with its patch panel/switch port ID.

1. Labeling must be printed – no handwritten labels will be allowed.

I. At the completion of the wiring installation, the Engineer will be provided with the following documentation:

1. A plan-view of the premise(s) showing the jack numbering scheme.
2. A printed certification report for the entire wiring installation showing compliance with all ANSI/EIA/TIA specifications for data cable.
3. Reports such as those generated by Fluke DSP cable certification equipment meet this requirement.

3.3 FIELD QUALITY CONTROL

A. LAN Cable Testing:

1. Testing scope: Test all installed LAN cables.
2. Test plan and witnessing: Obtain Engineer's approval for the test procedures as part of the submittal process. Arrange for the Engineer to witness all testing. Submit a request for witness 15 days (minimum) prior to the proposed test date.
3. Pre-testing:

a. Test individual cables before installation.

1) Prior to physical placement of the cable, the installer shall test each cable while on the spool with a LAN certification test device.
2) Before the cable is installed the installer shall check that the cable conforms to the Manufacturer's attenuations specification and that no damage has been done to the cable during shipping or handling.
3) The test shall be fully documented and the results submitted to the Engineer, including a hard copy of the all traces, prior to placement of the cable.
4) The Engineer shall be notified if a cable fails to meet specification and the cable shall not he installed unless otherwise directed by the Engineer.

4. Test Equipment

a. LAN Certification equipment used for the testing shall be capable of testing Category 6 cable installation to TIA proposed level III accuracy.

b. Tests performed shall include:

1) Near end cross talk
2) Attenuation

3) Equal level far end cross talk

4) Return loss

5) Ambient noise

6) Effective cable length

7) Propagation delay

8) Continuity/loop resistance

c. LAN certification test equipment shall be able to store and produce plots of the test results.

d. Manufacturers – One of the following:

1) Agilent Technologies, WireScope 350.

2) Or approved equal.

3.4 ADJUSTING

A. Perform all firmware installations, configuration and other set up, as required, to place the network into proper operation.

3.5 PROTECTION

A. Protect all network equipment after installation and before commissioning. Replace any hardware damaged prior to commissioning.

1. The Engineer shall be the sole party responsible for determining the corrective measures.

END OF SECTION

SECTION 16710

CONTROL SYSTEMS – PANELS, ENCLOSURES AND COMPONENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes requirements for:

1. Design, fabrication and assembly requirements for all instrumentation enclosures, control panels and components provided under this contract, including but not limited to:

a. Custom built instrumentation and control panels, including PCMs, PLCs, LCPs, Instrument Junction boxes (IJBs) and power junction boxes (PJBs) etc.

b. Control panels furnished as part of equipment systems specified in other Divisions, such as vendor control panels (VCP) and chemical feed panels.

c. Control components.

d. Control panel fabrication and installation.

e. Interfaces between control panels and the SCADA/PLC System.

B. Related Sections:

1. The Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the CONTRACTOR and its Subcontractors to review all sections to ensure a complete and coordinated project.

1.2 REFERENCES

A. Specific References:

1. National Electrical Code (NEC): NFPA 70.

2. National Electrical Manufacturer's Association (NEMA):

a. NEMA 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum).

b. NEMA ICS 6 - Enclosures for Industrial Control and Systems.

3. Underwriters Laboratories Inc. (UL):

a. UL 50 - Enclosures for Electrical Equipment.

b. UL 508 - Industrial Control Equipment.

c. UL 508A - Standard for Industrial Control Panels.

1.3 DEFINITIONS

A. Specific Definitions:

1. The term “panel” in this Section is interchangeable with the term “enclosure.”

1.4 SYSTEM DESCRIPTION

A. Provide enclosures suitable for the location and environmental conditions in which they are located, unless otherwise indicated.

B. Panel Dimensions:

1. Minimum dimensions are scalable from or as indicated on the Drawings and are based upon manufacturer's non-certified information. It is the responsibility of the Contractor or Manufacturer to design and size all panels:

a. Size panels to provide space for all equipment, wiring, terminations, and other items in the panel, including space for future build out.

b. Panel sizes that substantially deviate (± 3 inches in any dimension) from the sizes shown on the Drawings must be approved by the ENGINEER.

c. Maximum panel depth: 30 inches, unless otherwise indicated.

C. Structural Design:

1. Completed and installed panel work shall safely withstand "seismic requirements". Enclosures and internal equipment shall be braced to prevent damage from specified forces.

1.5 SUBMITTALS

A. Provide a two phase control panel hardware submittal, for each control panel and enclosure being provided on this project, including but not limited to:

1. Product Data:

a. Enclosure construction details and NEMA type.

b. Manufacturer's literature and specification data sheets for each type of basic material to be installed within or on the panel or enclosure.

2. Shop Drawings:

a. Scaled, detailed exterior panel (front and side views) and interior panel layout showing equipment arrangement and dimensional information:

1) Provide draft for review and approval of ENGINEER. The ENGINEER has the authority to substantially alter initial panel layouts.

b. Complete nameplate engraving schedule.

c. Structural details of fabricated panels.

3. Calculations – Seismic considerations

a. Provide installation details based on calculated shear and tension forces:

1) Calculations shall be signed and sealed by a Professional Engineer licensed in the state where the cabinets and panels will be installed.

b. For assembled enclosures and other equipment with a weight of 200 pounds or more, provide calculations for:

1) Weight including panel internal components.

2) Seismic forces and overturning moments.

3) Shear and tension forces in connections.

4. Calculations – Heat Release

a. Cooling Calculations, to include but not limited to:

1) Highest expected ambient temperature for the enclosure's location

2) Internal heat load:

3) Exposure to direct sunlight.

4) Dimensions of the enclosure in inches.

5) Maximum desired temperature inside the enclosure.

B. Phase I shall be the Control Panel Hardware submittal which shall include but not be limited to:

1. Enclosure construction details and NEMA type.
2. Finish, including color chart for ENGINEER selection of color.
3. Layout.
4. Power circuits.
5. Signal and safety grounding circuits.
6. Fuses.
7. Circuit breakers.
8. Signal circuits.
9. Internally mounted instrumentation.
10. PLCs.
11. SCADA system components.
12. Face plate mounted instrumentation components.
13. Internal panel arrangements.
14. External panel arrangements.
15. Construction drawings drawn to scale which define and quantity.
16. The type and gage of fabrication steel to be used for panel fabrication.
17. The ASTM grade to be used for structural shapes and straps.
18. Panel door locks and hinge mechanisms.
19. Type bolts and bolt locations for section joining and anchoring.
20. Details on the utilization of "UNISTRUT" and proposed locations.
21. Stiffener materials and locations.
22. Electrical terminal box and outlet locations.

23. Electrical access locations.
24. Print pocket locations.
25. Writing board locations.
26. Lifting lug material and locations.
27. Physical arrangement drawing drawn to scale which define and quantity the physical groupings comprising:
28. Control panel sections.
29. Auxiliary panels.
30. Subpanels.
31. Racks.
32. Cutout locations with nameplate identifications shall be provided.
33. A bill of material which enumerates all devices associated with the control panel.

C. Phase II shall be the Control Panel Wiring Diagram submittal which shall include but not be limited to:

1. Schematic/Elementary diagrams shall depict all control devices and circuits and their functions.
2. Wiring/Connection diagrams shall locate and identify:
3. Electrical devices.
4. Terminals.
5. Interconnecting wiring.
6. These diagrams shall show interconnecting wiring by lines, designate terminal assignments, and show the physical location of all electrical and control devices.
7. Interconnection diagrams shall locate and identify all external connections between the control panel/control panel devices and associated equipment.
8. These diagrams shall show interconnecting wiring by lines, designate terminal assignments, and show the physical location of all panel ingress and egress points.
9. Control sequence diagrams shall be submitted to portray the contact positions or connections required to be made for each successive step of the control action.

D. Testing plans, forms, procedures, and other testing submittals.

1.6 QUALITY ASSURANCE

A. Assemble panels, enclosures, and rack systems along with all internal and external devices, wiring, equipment, and materials in a facility that is recognized by Underwriters Laboratories to assemble and certify UL-labeled control panels:

1. Provide all components and equipment with UL508 listing.

2. All control panels shall be UL 508A labeled, unless the equipment in the panel and the design in the contract documents cannot be reasonably modified to meet the requirements for UL508A labeling.

1.7 DELIVERY, STORAGE AND HANDLING

A. Crate all panels for shipment using a heavy framework and skids:

1. Provide factory-wrapped waterproof flexible barrier material for covering materials, where applicable, to protect against physical damage in transit.

2. Provide suitable shipping stops and cushioning material for all instruments shipped with the panel to prevent damage due to mechanical shock during shipment.

3. Provide each separate panel unit with removable lifting lugs to facilitate handling.

B. Ship all panels by dedicated air ride van, unless otherwise specified or approved.

1.8 PROJECT OR SITE CONDITIONS

A. Environmental Suitability:

1. Provide all control panels and instrument enclosures that are suitable for operation in the site conditions associated with the locations designated in the Contract Documents or as indicated on the Drawings including, but not limited to, material compatibility, site altitude, site seismic, ambient temperature, and humidity conditions.

2. Intrinsically safe.

1.9 SEQUENCING

1.10 WARRANTY

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. As listed below in the individual component paragraphs.

B. Provide instruments and other components performing similar functions of the same type, model, or class, and from one Manufacturer.

2.2 MATERIALS

A. Construct and finish enclosures using materials capable of withstanding the mechanical, electrical, and thermal stresses, as well as the effects of humidity and corrosion that are likely to be encountered in normal service:

1. Enclosures shall have the following properties:

a. NEMA 1: Steel.

b. NEMA 4: With gasketed door, rain-tight.

1) Outdoor: Stainless steel.

2) Indoor: Stainless steel.

c. NEMA 4X: With gasketed door, rain-tight.

1) Outdoor: Stainless steel.

2) Indoor: Stainless steel.

d. NEMA 12: Polycarbonate or fiberglass reinforced polyester (FRP) with gasketed door, dust-tight.

e. NEMA 7: Cast aluminum.

B. Bolting Material:

1. Commercial quality 1/2-inch diameter, plated carbon steel hex-head grade 5 bolts, nuts and washers, with unified coarse (UNC) threads.

2. Carriage bolts shall be used for attaching end plates.

3. All other bolted joints shall have S.A.E. standard lock washers.

2.3 MANUFACTURED UNITS

A. Panels/Enclosures:

1. Manufacturers:

a. One of the following:

1) Rittal.

2) Hoffman Engineering.

3) Saginaw Control & Engineering.

4) Prior-approved equal.

2. Panel assembly:

a. General guidelines for panel fabrication include:

1) Continuous welds ground smooth.

2) Exposed surfaces free of burrs and sharp edges.

3) Base formed of heavy channel iron, either galvanized or powder coated, minimum 1/2 inch holes at 12 inch spacing to accommodate anchoring of freestanding enclosures to floor.

b. Construct enclosure and mounting panel using stretcher level sheet metal having minimum thickness not less than the following sizes (U.S. Standard Gauge):

Enclosure Height (inches)	Minimum Enclosure Steel Thickness (gauge)	Minimum Back Mounting Panel Thickness (gauge)
Up to 57	12	12
57 – 69	12	10
69 – 82	12, except 10 on back	10
82 or more	10	10

1) Use heavier sheet metal to meet seismic requirements as specified.

c. Construct supporting frame structure with angled, channeled, or folded rigid section of sheet metal, rigidly attached to and having essentially the same outer dimensions as the enclosure surface and having sufficient tensional rigidity to resist the bending moments applied via the enclosure surface when it is deflected.

d. Provide stiffeners for back mounting panels in enclosures larger than 4 feet. In addition, secure the panels in place by collar studs welded to the enclosure.

e. Doors construction:

1) Turned-back edges suitably braced and supported to maintain alignment and rigidity without sagging.

2) Sufficient width to permit door opening without interference with rear projection of flush mounted instruments.

3) Heavy gauge, piano type, continuous stainless steel hinges.

4) Oil resistant neoprene sealing gasket and adhesive to seal cover to enclosure.

5) Gasket installed to seal against roll lip on the enclosure opening.

f. Latches:

1) For panels, other than large types NEMA 4 and 4X, each door provided with a 3-point latching mechanism and padlocking handle with rollers on the ends of the latch rods. Latch rods connected to a common door handle, hold doors securely, forming a compressed seal between door and gasket, at the top, side, and bottom.

2) Include an oil-tight key-locking, 3-point latching mechanism on each door:

a) Provide 2 keys per panel.

b) All locks keyed the same.

3) For large type NEMA 4 and NEMA 4X cabinets, not available with 3-point latching hardware, provide multiple clips and padlock hasps.

g. Panel cut-outs:

1) Cut, punch, or drill cut-outs for instruments, devices, and windows. Smoothly finish with rounded edges.

2) Allow a minimum of 3 inch envelope around all devices.

3) Reinforce around cut-outs with steel angles or flat bars for the following:

a) Large panel cutouts; for example, openings for local operator interfaces.

b) Pilot device groupings, where the removed metal exceeds 50 percent of the available metal.

3. In addition to the requirements specified above, the following requirements for NEMA 4X stainless steel enclosures apply:

   a. Minimum 14 gauge stainless steel.

   b. Captive stainless steel cover screws threaded into sealed wells.

   c. Finish: Unpainted, brushed finish.

   d. Specifically designed for use with flange-mounted disconnect handles where required or as indicated on the Drawings.

4. In addition to the requirements specified above the following requirements for NEMA 4X non-metallic enclosures apply:

   a. Fiberglass construction.

   b. 10 gauge plate steel reinforcing on the sides, top, and bottom.

   c. All seams sealed.

   d. Fiberglass hinges with no exposed metal parts.

   e. Captivate stainless steel door screws.

   f. Provisions for internal, sidewall, mounting panels either by welded channels to the interior, or by welded collar studs.

   g. Provide aluminum mounting panels.

   h. Non-metallic enclosures are not an acceptable substitute for stainless steel unless indicated on the Drawings.

5. Outdoor Panels. Supplementary requirements for panels located outdoors are as follows:

   a. All enclosures located outdoors shall be explicitly designed and rated for outdoor service by the manufacturer.

   b. Finish: Other than stainless steel and fiberglass, the finish shall be outdoor-rated, baked powder coated over dip-coated primer.

   c. Door hardware: stainless steel.

   d. Bases: Heavy channel, gasketed iron bases, flanges up, for anchoring to pad.

   e. Provide rain canopy and sun shield.

6. Arrangement of Components:

   a. Arrange panel internal components for external conduit and piping to enter into panel either from above or below.

   b. Arrange panel instruments and control devices in a logical configuration associating pushbutton and selector switches with related readout devices, or as indicated on the Drawings.

c. Mount internal control components on an internal back-panel. Devices may be mounted on the side-panel only by special permission from the ENGINEER.

d. Group cables, and firmly support wiring to the panel. Provide minimum 8 inches clearance between terminal strips or wiring duct and the base of the enclosure for conduit and wiring space.

e. All control panel mounted operator interface devices shall be mounted between 3 feet and 6 feet above finished floor.

7. Grounding:

a. Provide the following equipment grounding system:

1) Equipment grounding conductors and equipment bonding jumpers.

2) Equipment grounding conductor terminals.

3) Conductive structural parts of the enclosure.

b. Ensure the continuity of the equipment grounding system by effective connections through conductors or structural members.

c. Size ground wires in accordance with NEC and UL Standards, unless noted otherwise.

d. Provide equipment ground bus with lugs for connection of all equipment grounding wires.

e. Connect all exposed, noncurrent-carrying conductive parts, devices, and equipment shall be connected to the equipment grounding circuit.

f. Provide an equipment grounding terminal for each incoming power circuit, in the vicinity of the phase conductor terminal.

g. Design so that removing a device does not interrupt the continuity of the equipment grounding circuit.

h. Identify equipment grounding conductor terminals with the word “GROUND,” the letters “GND” or the letter “G,” or the color green.

i. Connect the door stud on the enclosures to an equipment-grounding terminal within the enclosure using an equipment-bonding jumper.

j. Signal (24 VDC) Grounding: Terminate each drain wire of a signal (shielded) cable to a unique grounding terminal block, or common ground bus at the end of the cable as shown on the Loop Drawings.

1) Bond multi-section panels together with an equipment grounding conductor or an equivalent grounding bus sized in accordance with NEC Table 250.122.

2) Bond together all PLC or RTU racks (remote or local) processor racks, and conductive enclosures of power supplies and connect to the equipment grounding circuit.

k. Protection:

1) Provide disconnecting, short-circuit, and overcurrent protection for all control panels.

2) Select and apply protective devices with proper consideration given, but not limited to the following:

a) System maximum available fault current at the point of application.

b) Interrupting rating of the protective device.

c) Voltage rating of the system.

d) Load and circuit characteristics:

1. Normal operating current.

2. Inrush characteristics.

3. Thermal withstand capability (I^2t).

4. Magnetic withstand capability (I_p).

e) Current-limiting ability of the protective device.

f) Coordination of the protective devices to each other.

3) Provide a separate protective device for each 120 VAC powered electrical device.

4) Each 120 VAC Control Loop and Instrument shall have an individual circuit breaker within its respective control panel and clearly identified for function.

5) Each 120 VAC and 24 VDC PLC output shall have its own individual fuse external of the I/O card with blown fused indication:

a) Size external fuse to open before any I/O card mounted fuses.

6) Provide a protective fuse device for each PLC discrete output coordinated to open before the protective device on the PLC I/O card.

7) Protective devices shall be located on the back mounting panel and identified by a service nameplate in accordance with the wiring diagrams.

8) Provide dedicated single pole circuit breakers, one for the panel lighting luminaire(s), and one for the panel receptacle(s):

a) 15 amperes, 120VAC.

9) The power entrance to each panel shall be provided with a surge protection device. Surge protectors shall be nominal 120 volts ac with a nominal clamping voltage of 200 volts. Surge protectors shall be a non-faulting and non-interrupting design with a response time of less than 0.5 nanoseconds in normal mode and less than 5 nanoseconds in normal mode Peak surge current capability shall be rated for at least 15,000 amps, line to neutral, line to ground and neutral to ground.

I. Manufacturer: Control Concepts Model IC + 130/IC + 130WL rated 30 amps, or as directed.

8. Conductors and Cables:

a. Power and Control Wiring:

1) Materials: Stranded, soft annealed copper.

2) Insulation: 600V type MTW.

3) Minimum Sizes:

a) Primary power distribution: 12 AWG.

b) Secondary power distribution: 14 AWG.

c) Control: 16 AWG.

4) Color:

a) AC power (line and load): BLACK.

b) AC power (neutral): WHITE.

c) AC control: RED.

d) DC power and control: BLUE.

e) Ground: GREEN.

b. Signal Cables:

1) Materials: Stranded, soft annealed copper.

2) Insulation: 600V, PVC outer jacket.

3) Minimum Size: 16 AWG paired triad.

4) Overall aluminum shield (tape).

5) Copper drain wire.

6) Color:

a) 2 Conductor:

b) Positive (+): BLACK.

c) Negative (-): WHITE, RED.

7) 3 Conductor:

a) Positive (+): BLACK.

b) Negative (-): RED.

c) Signal: WHITE.

8) Insulate the foil shielding and exposed drain wire for each signal cable with heat shrink tubing.

9. Conductor Identification:

a. Identify all conductors and cables with wire markers.

b. Readily identified without twisting the conductor.

10. General Wiring Requirements:

a. Wiring Methods: Wiring methods and materials for panels shall be in accordance with the NEC requirements for General Purpose (no open wiring) unless otherwise specified.

b. Install all components in accordance with the manufacturer’s instructions included in the listing and labeling.

c. Where the electrical power supply voltage to the control panel is more than 120 VAC, provide the panel with a control power transformer and flange mounted disconnect. The disconnect shall be mechanically interlocked with the control enclosure doors so that no door can be opened unless the power is disconnected. Interlocking shall be reactivated automatically when all the doors are closed.

d. Control panels supplied with 120 VAC:

   1) Provide an internal breaker with the line side terminals covered by a barrier.

   2) Provide a nameplate prominently positioned on the control panel identifying the location of the power source and a warning statement requiring that the source be disconnected before opening the door to the enclosure.

3) Provide a nameplate on the cover of the control panel identifying all sources of power supply and foreign voltages within the control panel.

4) Provide transformers, protective devices, and power supplies required to convert the supply voltage to the needed utilization voltage.

5) Provide surge protection device on input supply power.

6) Provide nonmetallic ducts for routing and organization of conductors and cables:

   a) Size ducts for ultimate build-out of the panel, or for 20 percent spare, whichever is greater.

   b) Provide separate ducts for signal and low voltage wiring from power and 120 VAC control wiring:

      1. 120 VAC: Grey colored ducts.

      2. 24 VDC: White colored ducts.

7) Cables shall be fastened with cable mounting clamps or with cable ties supported by any of the following methods:

   a) Screw-on cable tie mounts.

   b) Hammer-on cable tie mounting clips.

   c) Fingers of the nonmetallic duct.

8) The free ends of cable ties shall be cut flush after final adjustment and fastening.

9) Provide supports at the ends of cables to prevent mechanical stresses at the termination of conductors.

10) Support panel conductors where necessary to keep them in place.

11) Wiring to rear terminals on panel-mount instruments shall be run in nonmetallic duct secured to horizontal brackets run adjacent to the instruments.

12) Conductors and cables shall be run from terminal to terminal without splice or joints. Exceptions:

a) Factory applied connectors molded onto cables shall be permitted. Such connectors shall not be considered as splices or joints.

13) The control panel shall be the source of power for all 120 VAC devices interconnected with the control panel including, but not limited to:

a) Solenoid valves.

b) Instruments, both mounted in the control panel and remotely connected to the control panel.

e. Thermal Management:

1) Provide heating, cooling, and dehumidifying devices in order to maintain all instrumentation and control devices to within a range.

2) Air Conditioning:

a) Cooling:

1. Provide filtered, fan forced type cooling system for each control cabinet.

2. Size fans, louvers and filters to maintain a cabinet temperature no more than 10°F above ambient electrical room temperature.

3. Cooling system includes the following components:

4. Ventilation fans with louver and filter.

5. Relief air louvers.

6. Thermostat.

7. 5 micron air filters for each opening.

b) Heating:

1. Provide all panels located in areas that is not climate controlled with thermostatically controlled strip heaters; except, where all of the following conditions apply:

2. The panel is not supplied with 120 VAC power.

3. There are no electronics or moisture-sensitive devices in the enclosure.

4. The panel is smaller than 38 inches high.

3) Enclosure Temperature Sensor:

a) Wall mount RTD sensor to measure internal cabinet temperature.

b) Platinum RTD.

c) 4-20 mA output.

d) Sensor and electronic enclosure.

e) Accuracy: ±2.0 degrees Fahrenheit.

1. Manufactured by:

a. Omega, EWS series

b. TCS Basys Controls, TS Series

2.4 COMPONENTS

A. Panel Meters:

1. Digital:

a. Self-contained instruments that display process signals directly in engineering units.

b. Suitable for panel mounting.

c. LED display:

1) 0.56-inch height.

2) Multi-range capabilities.

3) Integral provisions for scaling.

4) Switch programmable decimal points.

5) NEMA 4/IP65 sealed front metal bezel.

d. Current and Voltage indicators:

1) 3 1/2 - digit.

e. Accuracy:

1) AC/DC volts: ± (0.1 percent of reading + 2 digit).

2) DC current:

a) 4 - 20mA: ± (0.1 percent of reading + 1 digit).

b) 0 - 10V: ± (0.1 percent of reading + 1 digit).

3) Ratings, protection, and indication:

a) Maximum applied voltage: 300 VAC/VDC.

f. Operating voltage: 120 VAC.

g. Operating temperature: 0 degrees Celsius to 60 degrees Celsius.

1) Manufacturer, One of the following

a) Red Lion.

B. Manual Operator Interface Devices:

1. General:
    a. Provide operator pushbuttons, switches, and pilot lights, from a single manufacturer.
    b. Size:
        1) 30.5mm.
    c. Lamp Color:
        1) On/Running/Start/Open: Green.
        2) Close/Off/Stop: Red.
        3) Power: White.
        4) Alarm: Red.
        5) Status or Normal Condition: White.
        6) Opened: Amber.
        7) Closed: Blue.
        8) Failure: Red.
2. Indoor and Outdoor Areas:
    a. NEMA type 4/13.
    b. Heavy duty.
    c. Pushbutton:
        1) Contacts rated:
            a) NEMA A600.
        2) Furnish one spare normally open and normally closed contact with each switch.
        3) Provisions for locking in the OFF position where lockout provisions are indicated on the Drawings.
        4) Manufacturer: One of the following:
            a) Allen Bradley Type 800T.
            b) Square D Class 9001 Type K.
            c) General Electric Type CR104P.
            d) IDEC TWTD.
    d. Selector switches:
        1) Contacts rated:
            a) NEMA A600.
            b) Knob type:
        2) Manufacturer: One of the following
            a) Allen Bradley Type 800T.
            b) Square D Class 9001 Type K.

c) General Electric Type CR104P.

d) IDEC TWTD.

3) Furnish one spare normally open contact and normally closed contact with each switch.

4) Provisions for locking in the OFF position where lockout provisions are indicated on the Drawings.

e. Pilot lights:

1) Type:

a) LED for all interior installations.

b) Full Voltage for exterior installations.

2) Push to Test.

3) LED Lamp.

4) Manufacturer: One of the following

a) Allen Bradley Type 800T.

b) Square D Class 9001 Type K.

c) General Electric Type CR104P.

d) IDEC TWTD.

3. Corrosive Areas:

a. NEMA 4X.

b. Exterior parts of high impact strength fiberglass reinforced polyester.

c. Pushbutton:

1) Contacts rated:

a) NEMA A600.

2) Manufacturer: One of the following:

a) Cutler Hammer Type PB2.

b) Square D Class 9001 Type SK.

c) Allen Bradley Type 800H.

d) IDEC TWTD.

d. Selector switches:

1) Contacts rated:

a) NEMA A600.

b) Knob Type:

2) Manufacturer: One of the following:

a) Cutler Hammer Type E34.

b) Square D Class 9001 Type SK.

c) Allen Bradley Type 800H.

d) General Electric Type CR104P.

e) IDEC TWTD.

e. Pilot lights:

1) Type:

a) LED for all interior installations.

b) Full Voltage for exterior installations.

2) Corrosion resistant.

3) Push to test.

4) Manufacturer: One of the following:

a) Cutler Hammer Type E34.

b) Square D Type SK.

c) Allen Bradley Type 800H.

4. Hazardous (Classified) Areas/Class I Division I:

a. NEMA 7.

b. High impact strength fiberglass reinforced polyester.

c. Pushbutton:

1) Contacts rated:

a) NEMA B600.

b) Contacts contained within a hermetically sealed chamber.

c) UL listed and labeled for Class I Division 2 areas.

2) Manufacturer: One of the following

a) Allen Bradley Type 800H.

d. Selector switches:

1) Contacts rated:

a) NEMA B600.

b) Contacts contained within a hermetically sealed chamber.

c) UL listed and labeled for Class I Division 2 areas.

d) Knob Type:

2) Manufacturer: One of the following:

a) Allen Bradley Type 800H.

e. Pilot lights:

1) Type:

a) LED for all interior installations.

b) Full Voltage for exterior installations.

2) Corrosion resistant.

3) UL listed and labeled for Class I Division 2 areas.

4) Push to test.

5) Manufacturer: One of the following:

a) Allen Bradley Type 800H.

5. Potentiometer and Slide wire Transmitters:

a. Provide a DC output in proportion to a potentiometer input.

b. Potentiometer input:

1) 100 ohms to 100K ohms.

2) Impedance ≥ 1M ohms.

3) Zero Turn-Up: 80 percent of full scale input.

4) Span Turn-Down: 80 percent of full scale input.

c. Field configurable output:

1) Voltage and Current: All conventional current loops and voltage control signals.

d. Accuracy including linearity and hysteresis ± 0.1 percent max at 25 degrees Celsius.

e. Operating temperature: 0 degrees Celsius to 55 degrees Celsius.

f. Supply power: 9 to 30 VDC.

g. Manufacturer: One of the following:

1) Phoenix Contact.

C. Signal isolators and converters:

1. Furnish signal isolators that provide complete isolation of input, output, and power input:

a. Minimum isolation level: 1.5 kV AC/50 Hz for at least 1 minute.

b. Signal input: All conventional current loops and voltage control signals.

c. Signal output: All conventional current loops and voltage control signals.

d. Operating voltage: As shown on the Drawings.

e. Adjustable span and zero.

f. Accuracy: ± 1.0 percent of span.

g. Ambient temperature range: -20 degrees Celsius to +65 degrees Celsius.

h. DIN rail mounting on 35mm rail.

i. Wire connection: Pluggable terminal blocks.

D. Relays:

1. General:
    a. For all types of 120 VAC relays, provide transient surge protection across the coil of each relay.
    b. For all types of 24 VDC relays, provide a free-wheeling diode across the coil of each relay.
2. General Purpose:
    a. Magnetic control relays.
    b. NEMA A300 rated:
        1) 300 Volts.
        2) 10 Amps continuous.
        3) 7,200 VA make.
        4) 720 VA break.
    c. Plug-in type.
    d. LED indication for relay energized.
    e. Coil voltages: As indicated on the Drawings.
    f. Minimum poles: 2PDT.
    g. Touch safe design: All connection terminals to be protected against accidental touch.
    h. Enclose each relay in a clear plastic heat and shock-resistant dust cover.
    i. Quantity and type of contact shall be as shown on the Drawings or as needed for system compatibility.
    j. Sockets for relays shall have screw-type terminals.
    k. Provide additional (slave/interposing) relays when the following occurs:
        1) The number or type of contacts shown exceeds the contact capacity of the specified relays.
        2) Higher contact rating is required in order to interface with starter circuits or other equipment.
    l. DIN rail mounting on 35mm rail.
    m. Ice Cube type relays shall be provided with retainer clips to secure relay in socket.
    n. Integrated label holder for device labeling.
    o. Manufacturer: One of the following:
        1) Phoenix Contact PLC series.
        2) Potter and Brumfield Type KRP or KUP.
        3) IDEC R* series. (* = H, J, R, S, U).
        4) Allen Bradley Type 700 H Series.
        5) Square D Type K.

6) Turck

3. Machine Tool Relays:

a. Magnetic industrial relays.

b. NEMA A600 rated:

1) 600 Volts.

2) 10 Amps continuous.

3) 7,200 VA make.

4) 720 VA break.

c. Coil voltage: As indicated in the Contract Documents.

d. Convertible contact cartridges to convert any contact from a normally open to a normally closed configuration.

e. Contact cartridges shall have a clear cover for visual inspection.

f. Contact material shall be fine grade silver.

g. Minimum number of poles: 4 Type “A” or Type “B”, or as indicated on the Drawings, plus 1 spare.

h. Machine tool type.

i. Touch safe design: All connection terminals to be protected against accidental touch.

j. Integrated label holder for device labeling.

k. DIN rail mounted on 35mm rail.

l. Manufacturer: One of the following

1) Allen Bradley type 700P.

2) Square D type 8501XO.

3) Cutler Hammer D15 series.

4. Latching:

a. Magnetic latching control relays.

b. NEMA B300 rated:

1) 300 Volts.

2) 10 Amps continuous.

3) 3,600 VA make.

4) 320 VA break.

c. Plug-in type.

d. DIN rail mounting on 35mm rail.

e. Coil voltage: 120 VAC.

f. Minimum poles: 2PDT; as indicated on the Drawings, plus 1 spare.

g. Touch safe design: All connection terminals to be protected against accidental touch.

h. Clear cover for visual inspection.

i. Provide retainer clip to secure relay in socket.

j. Manufacturer:

    1) One of the following, or equal:

        a) Square D type 8501 Type K.

        b) IDEC TWTD.

5. Time Delay:

    a. Provide time delay relays to control contact transition time.

    b. NEMA A300 rated:

        1) 300 Volts.

        2) 10 Amps continuous.

        3) 7,200 VA make.

        4) 720 VA break.

    c. Plug-in type.

    d. DIN rail mounting on 35mm rail.

    e. Coil voltage: as indicated in Contract Documents.

    f. Provide Electronic type with on-delay, off-delay, and on/off delay.

    g. Minimum poles: 2PDT; as indicated on the Drawings, plus minimum 1 spare.

    h. Units shall include adjustable dial with graduated scale covering the time range in each case.

    i. Minimum timing range: 0.1 seconds to 10 minutes.

    j. Manufacturer: One of the following:

        1) Agastat type Series 7000.

        2) Allen Bradley type 700HR.

E. Terminal blocks:

1. Din rail mounting on 35mm rail.

2. Suitable for specified AWG wire.

3. Rated for 30 amperes at 600 Volts.

4. Screw terminal type.

5. Provide mechanism to prevent wire connection from loosening in environments where vibration is present. This mechanism shall not cause permanent deformation to the metal body.

6. Finger safe protection for all terminals for conductors.

7. Construction: Polyamide insulation material capable of withstanding temperature extremes from - 40 degree Celsius to degree 105 Celsius.
8. Terminals: Plainly identified to correspond with markings on the diagrams:
   a. Permanent machine printed terminal identification.
9. Identify terminals suitable for use with more than 1 conductor.
10. Position:
    a. So that the internal and external wiring does not cross.
    b. To provide unobstructed access to the terminals and their conductors.
11. Provide minimum 25 percent spare terminals.
12. Manufacturer: One of the following:
    a. Phoenix Contact UK5 Series.
    b. Entrelec M4/6.
    c. Allen Bradley Series 1492.
13. Wire duct:
    a. Provide flame retardant plastic wiring duct, slotted with dust cover.
    b. Type:
       1) Wide slot.
       2) Narrow slot.
       3) Round hole.
    c. Manufacturer: One of the following:
       1) Panduit.
14. Fuses (holders) and circuit breakers:
    a. Fuse holders:
       1) Modular type:
          a) DIN rail mounting on 35mm rail.
          b) Touch safe design: All connection terminals to be protected against accidental touch.
          c) Incorporates blown fuse indicator.
       2) Provide nameplate identifying each fuse:
          a) In accordance with Section 16075.
       3) Manufacturer: One of the following:
          a) Phoenix Contact.
          b) Entrelec.
          c) Allen Bradley 1492-FB Series B.
15. Control Circuit Breakers:

a. DIN rail mounting on 35mm rail.

b. Manual OPEN-CLOSE Switch.

c. Rated 250 VAC.

d. Interrupt Rating: As indicated on the Drawings.

e. Current ratings: As indicated on the Drawings.

f. Provide nameplate identifying each circuit breaker, refer:

   1) In accordance with Section 16075.

g. Manufacturer: One of the following:

   1) Phoenix Contact.

   2) ABB.

   3) Allen Bradley Series.

   4) Square D.

   5) Entrelec.

F. Transient / Surge Protection Devices:

1. Provide Surge Protection Device (SPD) for Power Entrances:

   a. Nominal 120 VAC with a nominal clamping voltage of 200 Volts.

   b. Non-faulting and non-interrupting design.

   c. A response time of not more than 5 nanoseconds.

2. Control Panel Power System Level Protection, non-UPS powered:

   a. Design to withstand a maximum 10 kA test current of a 8/20µs waveform according to ANSI/IEEE C62.41.1-2002 Category C Area.

   b. Provide both normal mode noise protection (between current carrying conductors) and common mode (between current carrying conductor and neutral) surge protection.

   c. DIN rail mounting.

   d. Attach wiring to the SPD by means of a screw type cable-clamping terminal block:

      1) Gas-tight connections.

      2) The terminal block: Fabricated of non-ferrous, non-corrosive materials.

   e. Visual status indication of MOV status on the input and output circuits.

   f. Dry contact rated for at least 250 VAC, 1 Amp for remote status indication.

   g. Meeting the following requirements:

      1) Response time: ≤ 100 ns.

      2) Attenuation: ≥ - 40dB at 100 kHz as determined by a standard 50 ohms insertion test.

3) Safety approvals:

a) UL 1283 (EMI/RFI Filter).

b) UL 1449 2nd Edition.

h. Manufacturer: One of the following:

1) Phoenix Contact type SFP TVSS/Filter.

2) Liebert Accuvar series.

3) Islatrol.

3. Data and Signal Line Protectors – Panel Mounted:

a. Surge protection minimum requirements: Withstand a 10 kA test current of a 8/20µs waveform in accordance with ANSI/IEEE C62.41.1-2002 Category C Area.

b. DIN rail mounting on 35mm rail (except field mounted SPDs).

c. SPD’s consisting of 2 parts:

1) A base terminal block.

2) A plug protection module:

a) Replacing a plug shall not require the removal of any wires nor interrupt the signal.

b) Base and plug shall have the ability to be coded to accept only the correct voltage plug.

d. SPD Manufacturer: One of the following:

1) Phoenix Contact Plugtrab Series.

2) Joslyn JMD Series.

4. Data and Signal Line Protectors – Field Mounted:

a. Surge protection minimum requirements: Withstand a minimum 10 kA test current of a 8/20µs waveform in accordance with ANSI/IEEE C62.41.1-2002 Category C Area.

b. Manufacturer: One of the following:

1) Phoenix Contact type SFP TVSS/Filter.

c. SPD Manufacturer: One of the following:

1) Phoenix Contact Pipetrab.

2) Boxtrab.

3) Joslyn JMD Series.

G. Power supplies:

1. Design power supply systems so that either the primary or backup supply can be removed, repaired, and returned to service without disrupting the system operation.

2. Convert 120 VAC to 24 volt DC or other DC voltages required or as indicated on the Drawings.
3. Provide backup 24 VDC power supply units to automatically supply the load upon failure of the primary supply.
4. Provide power supplies configured as fully redundant units consisting of 2 power supplies connected with an automatic switchover unit with alarm contacts monitored by the PLC and alarmed in SCADA.
5. Sized to provide 40 percent excess rated capacity.
6. UL508C listed to allow full rated output without de-rating.
7. Provide fuse or short-circuit protection.
8. Provide a minimum of 1 set of dry contacts configured to change state on failure for monitoring and signaling purposes.
9. Output regulation: ± 0.05 percent for a 10 percent line change or a 50 percent load change:
    a. With remote voltage sensing.
10. Operating temperature range: 0 degrees Celsius to 50 degrees Celsius.
11. Touch safe design: All connection terminals to be protected against accidental touch.
12. DIN rail mounting on 35mm rail.
13. Provide self-protecting power supplies with a means of limiting DC current in case of short circuit.
14. Manufacturer: One of the following:
    a. Phoenix Contact Quint series.
    b. IDEC PS5R series.
    c. Sola.
    d. Acopian.
    e. Puls.

H. Intrinsic Safety Barriers:
1. Transformer isolated barrier:
    a. Containing a transformer to provide complete:
        1) Isolation between the safe and hazardous areas for loop powered devices.
        2) 3-way isolation between the safe area, hazardous area and power supply powered devices.
    b. Resistor for current limitation.
    c. Fuses for short circuit protection.
    d. Provide barriers with pluggable connectors that are coded for easy replacement.

e. Transmission error shall be less than or equal to 0.1 percent of full scale.

f. DIN rail mounted on 35mm DIN rail.

g. Approvals:

1) FM.

2) UL 913 & 1604.

2. Types:

a. Switch Isolators:

1) Designed and approved for use with discrete inputs.

2) Supply Power: 20-30VDC.

3) Output to track input.

4) With an LED in the cover to indicate the status of the input.

5) With a selector switch to change the logic of the input.

6) Input - dry contact.

7) Output - SPDT relay.

b. Transmitter and Converters for use with 4-20 mA signals without Hart® communications capability:

1) Designed and approved for use with 4-20 mA analog signals.

2) Designed for powering 2 and/or 3 wire transmitters in hazardous locations and repeating and/or generating the current to the safe area.

3) Supply voltage: 20-30VDC.

c. Transmitter and converters for use with 4-20 mA signals with Hart® communications capability:

1) Designed and approved for use with 4-20 mA analog signals.

2) Designed for powering 2 and/or 3 wire transmitters in hazardous locations and repeating and/or generating the current to the safe area.

3) In addition, transfer digital signals from the hazardous area to the safe area.

4) Complete bi-directional communication between a smart transmitter located in the field and the suitable equipment located in the safe area.

5) Supply voltage: 20-30VDC.

3. Manufacturer: One of the following:

a. Phoenix Contact ME Series.

b. Pepperl + Fuchs.

c. Turck.

I. Disconnects and starters:

1. Flange Mounted Main Disconnect:

a. Rated 22KAIC or as required by the short circuit and coordination study specified in Section 16305, whichever is larger:

1) Size in accordance with the NEC, total connected horsepower and associated locked rotor current, and provide larger unit if needed based on any of these criteria.

b. Interlocked with the door of the control panel so that the door of the panel cannot be opened with the disconnect switch in the closed position, with defeater.

c. Door mounted disconnects are not acceptable.

d. Manufacturer: One of the following:

1) Allen Bradley - 1494.

2) Cutler Hammer - C361/C371.

3) ITE - FH011.

4) Square D - Class 94222.

2. Magnetic Motor Starters:

a. Minimum 22 KAIC or as required by the Short Circuit and Coordination study, which ever is larger.

3. Integral Self-Protected Starters:

a. In conformance with the requirements.

J. Limit Switches:

1. NEMA-4X.

2. AC contact rating 120V, 10A.

3. DC contact rating 125V, 0.4A.

4. DeviceNet Compatible as indicated in the drawings.

5. Provide robust actuation mechanism not prone to degradation.

6. Provide complete actuator mechanism with all required hardware.

7. Allows for contact opening even during contact weld condition.

8. UL approved.

9. Operating Temperature Range: -18 degrees to +110 degrees Celsius (0 degrees to 230 degrees Fahrenheit).

10. Manufacturer:

a. Allen Bradley 802.

b. Honeywell HDLS.

c. Omron D4.

d. Eaton E47, E49, E50.

e. ABB equal.

2.5 ACCESSORIES

A. Provide panels with an inside protective pocket to hold the panel Drawings. Ship panels with 1 copy of accepted Shop Drawings including, but not limited to, schematic diagram, connection diagram, and layout drawing of control wiring and components in a sealed plastic bag stored in the panel drawing pocket.

B. All enclosures which will have a computer mounted inside shall have a shelf to support the computer tower.

C. Provide 15 inch floor stands or legs where needed or as indicated on the Drawings.

D. Provide a folding shelf for enclosures that contain programmable controllers. The shelf shall be mounted on the inside surface of the door, capable of supporting a laptop computer.

E. Tag or identifying number of the panel as indicated on the Drawings.

1. Provide in accordance on all internal and external instruments and devices.
2. Provide a nameplate with the following markings that is plainly visible after installation:
    a. Manufacturer’s name, trademark, or other descriptive marking by which the organization responsible for the panel can be identified.
    b. Supply voltage, phase, frequency, and full-load current.
    c. Short-circuit current rating of the panel based on one of the following:
        1) Short-circuit current rating of a listed and labeled assembly.
        2) Short-circuit current rating established utilizing an approved method.

F. Provide a window kit where indicated on the Drawings. The window shall meet the following requirements:

1. Safety plate glass.
2. Secured by rubber locking seal.
3. Allow full viewing of devices issuing visual process data or diagnostics.

G. Luminaires:

1. Provide 1 luminaire, on the interior of the panel, located every 4 feet of enclosure width, spaced evenly along the top-front of the enclosure door opening(s):
    a. Covered or guarded.
    b. LED 40W max.
    c. Manual On-Off switches.

H. Receptacles:

1. Provide one duplex receptacle located every 4 feet of enclosure width, spaced evenly along the back mounting panels.

2. GFCI, 125-volt, single-phase, 15-ampere.

2.6 FINISHES

A. Finishes:

1. Metal surfaces of panels shall be prepared by chemical cleaning and mechanical abrasion in accordance with the finish manufacturer's recommendations to achieve a smooth, well-finished surface.

2. Scratches or blemishes shall be filled before finishing. One coat of zinc phosphate shall be applied per the manufacturer's recommended dry film thickness, and allowed to dry before applying the finish coat.

3. Finish coat shall be a baked polyester urethane powder, aliphatic air-dry polyurethane, or epoxy enamel to meet NEMA rating specified application.

4. Exterior of enclosures located outdoors shall be UV resistant polyester powder coating. Total dry film thickness shall be 3 mils, minimum.

B. Colors:

1. Exterior color of panels mounted indoors shall be manufacturer's standard light gray.

2. Exterior of panels mounted outdoors shall be manufacturer's standard white.

3. Panel interiors shall be manufacturer's standard white.

2.7 SOURCE QUALITY CONTROL

PART 3 - EXECUTION

3.1 EXAMINATION

3.2 INSTALLATION

A. Any components or panels damaged during installation shall be replaced.

B. Install enclosures so that their surfaces are plumb and level within ± 1/8 inch over the entire surface of the panel; anchor securely to wall and structural supports at each corner, minimum. Direct attachment to dry wall is not permitted.

C. Install the enclosure per guidelines and submitted installation instructions to meet the seismic requirements at the project site.

D. Provide floor stand kits for wall-mount enclosures larger than 48 inches high.

E. Provide 3-1/2 inch high concrete housekeeping pads for free-standing enclosures.

F. Install gasket and sealing material under panels with floor slab cutouts for conduit:

1. Undercoat floor mounted panels.

G. Provide a full size equipment-grounding conductor in accordance with NEC included with the power feeder. Terminate to the incoming power circuit-grounding terminal.

H. All holes for field conduits, etc. shall be cut in the field, there shall be no additional holes, factory cut holes, or hole closers allowed. Incorrect holes, additional holes, or miss-cut holes shall require that the entire enclosure be replaced.

I. Control panels that are adjacent to motor control centers shall be fully wired to the motor control centers using wireways integral to the motor control center or additional conduits as needed. These interconnections are not shown or reflected on the conduit schedule, but shall be shown on the Loop Drawings prepared by the CONTRACTOR.

3.3 FIELD QUALITY CONTROL

3.4 CLEANING

A. Clean area during construction.

3.5 PROTECTION

END OF SECTION

SECTION 16711

PROGRAMMABLE LOGIC CONTROLLER (PLC)

PART 1 - GENERAL

1.1 SCOPE

A. Furnish all labor, material, equipment, appliances, and perform all operations in connection with providing a complete and operable programmable logic controller (PLC) system in accordance with this section of the specifications and applicable drawings and subject to the terms and conditions of the Contract.

B. The SUPPLIER shall furnish a PLC control system utilizing Schneider Modicon M340 family of hardware as specified herein. No like, equal, or equivalent products will be considered.

C. The SUPPLIER shall furnish PLC programming software.

E. The CONTRACTOR'S programmer shall work in conjunction with the contractor to train the owner on the PLC system. The contractor shall train the owner on all hardware. The programmer shall train on PLC programming, SCADA programming, operations, fault clearing, start-up and shutdown procedures, etc.

F. The SUPPLIER and the CONTRACTOR will be one and the same for this contract. There will not be a separate contract for PLC programming.

1.2 APPLICABLE SECTIONS

A. The General Conditions, Supplementary General Conditions, Special Conditions, alternates and Addenda, applicable drawings and the technical specification herein shall apply to work under this Section.

1.3 APPLICABLE REFERENCES

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI X3.64 (1979) Additional Controls for Use with American National Standard Code for Information Interchange

ELECTRONIC INDUSTRIES ASSOCIATION (EIA)

EIA232-D (Jan. 1987) Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange

EIA RS-485 (1983) Standard for Electrical Characteristics of Generators and Receivers for Use in Balanced Multipoint System

FEDERAL COMMUNICATIONCOMMISSION (FCC)

FCC Part 68 (July 1986) Connection of Terminal Equipment to the Telephone Network

THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC. (IEEE)

IEEE No. 100	(1988) IEEE Standard Dictionary of Electrical and Electronic Terms
IEEE C57.13	(1978) Instrument Transformers
IEEE C62.41	(1980) Surge Voltages in Low-Voltage AC Power Circuits
IEEE 802.3	Carrier Sense Multiple Access/Collision Detection (CSMA/CD)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(1985; Incl. Rev. I and 2; ICS-6) Enclosures for Electrical Equipment
NEMA ICS 1	(1988) General Standards for Industrial Controls and Systems

UNDERWRITERS LABORATORIES, Inc. (UL)

UL 50	Enclosures for Electrical Equipment
UL 508	Industrial Control Equipment

1.4 SUBMITTALS

A. Provide complete submittal information for the PLC system. Include manufacturer's data for each part, Bill of Materials, panel fabrication drawings including elevations and complete wiring diagrams with wire and terminal numbers for local and remote terminations. Remote terminations may be submitted with the operational and maintenance information in lieu of the initial equipment submittals.

B. Provide operational and maintenance information.

1.5 RELATED SECTIONS

A. Static Un-Interruptible Power Supply

B. Control Devices

C. Appendix A

PART 2 - PRODUCTS

2.1 PROGRAMMABLE LOGIC CONTROLLER SYSTEM

A. The PLC system shall be Schneider Electric Modicon M340. Provide hardware types as identified in Table 1-1.

TABLE 1-1 PLC HARDWARE

Part Number

Modicon M340 CONTROL PROCESSOR

ETHERNET PORT

I/O Cards compatible with Modicon M340

Note: System to be installed per manufacturer recommended procedures and installation guidelines. Provide necessary hardware, accessories, fittings, cable, etc. for a complete and functioning system.

2.2 PLC ENCLOSURE AND ACCESSORIES

A. PLC Enclosure and Accessories: The PLC enclosure shall house the power supplies, PLC processor, analog input and output modules, discrete input and output modules, communication module, operator interface terminal (OIT), UPS, thermostatically controlled vent fan and louvers, heater with thermostat, light with integral door switch, relays, terminal blocks, and ancillary components. In addition, provide 25% spare back panel space and space for additional cards as indicated. The PLC shall be equipped with the following accessories, at a minimum:

1. Enclosure: The PLC shall be housed in a NEMA type12 enclosure with a lockable 3-point latch, and an interior swing out panel. The enclosure, swing out panel, vent fan, heater, and light shall be manufactured by Hoffman, or equal.
2. Redundant Power Supplies: Power supply hardware shall include a PLC power supply and redundant 24VDC power supplies as required for Inputs and Outputs (I/O). The redundant power supplies shall be 100 watt, minimum.
3. Fusing: Individual I/O loops shall be individually fused. Fuse holders shall be indicating type.
4. I/O Terminal Blocks: Field wiring DIN rail type terminal blocks. 25% spare terminal blocks shall be provided. Discrete and analog I/O terminals shall be segregated by I/O type.
5. Plastic Snap-On Cover Wire Management Systems: These shall be sized to accommodate all wiring with 25% spare capacity.
6. UPS System: A panel mounted UPS shall be included in each PLC cabinet. The UPS's shall be sized to provide at least 30 minutes of run time for the PLC and all system I/O. UPS systems shall be as specified elsewhere.
7. Transient Voltage Surge Suppression (TVSS): The TVSS system shall protect all power wiring within the PLC enclosure. The TVSS shall be a branch panel model.
8. Work Light and Outlet: A work light utilizing a 32 watt self ballasted compact fluorescent lamp or equal with an integral door operated switch shall be mounted within the enclosure. Enclosures over 4' wide shall include a light in each 4' section. A 20 amp, 120 volt duplex grounded power outlet shall be mounted within the PLC enclosure.
9. Ground Terminals: A screw type bonding terminal strip to which all ground bonding shall take place for all signal reference, TVSS, safety bonding etc. This grounding terminal shall accept a #6 copper ground bonding conductor. 25% spare terminals shall be provided.
10. Enclosure Labeling: The enclosure shall carry a phonetic label indicating the enclosure name, label all pilot devices on the swing out panel, and label all I/O termination modules, relays, power supplies, etc. Internal wiring shall be labeled at each terminal and each terminal shall be labeled, all labeling names and/or numbers shall be reflected on the panel fabrication drawings.

11. Separate Power Warning Signs: The enclosure shall receive power from external sources and shall be labeled with the source of where the external power is derived. Each circuit providing power to the cabinet shall be indicated.

B. Operator Interface Terminal (OIT/HMI): An OIT/HMI shall be mounted in the PLC enclosure swing-out panel. The OIT shall be 7" touchscreen or nearest available size compatible with PLC equipment, with keypad, 24VDC power, color graphics, and Ethernet communications operating from the terminal server with terminal services client software.

1. Provide OIT programming software to the OWNER, registered in OWNER's name.

2. Provide a programming cable for connection to a Personal Computer for the transfer of files.

2.3 INPUT/OUTPUT MODULES

A. Analog transmitters and receivers have 4 to 20 mA signals. Discrete (on/off) inputs (DI) originate from dry contacts. For discrete outputs (DO), provide interposing relays with dry contacts. Refer to the PLC Input / Output Point List, Appendix A, for required inputs and outputs.

B. The discrete input modules shall be 24 VDC.

C. The discrete output modules shall be isolated relay contacts suitable for operating interposing relays. Each discrete output module shall include fuses and fuse blown indicators.

D. The analog input (AI) modules shall be suitable for accepting 4 to 20 mA from 2, 3, or 4 wire transmitters. The input power shall be from an internal or external 24-volt dc power supply. The analog to digital converter shall have a 10-bit minimum resolution with an overall accuracy of ± .5% at 60ºC.

E. The analog output (AO) modules shall be 4 to 20 mA signals suitable for driving into a 0 to 600 ohm load without load adjustments. The digital to analog converter shall have a 10 bit minimum resolution with an overall accuracy of ± 2% to 60ºC. The output power shall be from an internal or external, 24 volt dc power supply provided by the SUPPLIER. If the PLC processor fails, the analog outputs shall retain their present value.

F. Discrete PLC I/O modules shall have individual LED status lights for each I/O point. All discrete and analog modules shall have terminal blocks for termination of the I/O wires. Individual I/O points shall be capable of withstanding low energy common mode transients to 1,500 volts.

2.6 PLC START-UP

A. Each PLC shall have start-up software that causes automatic commencement of operation without human intervention, including start-up of all connected I/O functions. A restart program based on detection of power failure shall be included in the software. Upon restoration of power, the program shall restart all equipment and restore all loads to the state at time of power failure, or to the state as commanded by time programs or other overriding programs. The restart program shall include start time delays between successive commands to prevent demand surges or overload trips. The start-up software shall initiate operation of self-test diagnostic routines. If the data base and application software are no longer resident or if the clock cannot be read, the PLC shall not restart and systems shall remain in the failure mode indicated until the necessary repairs are made. If the data base and application programs are resident, the PLC shall resume operation after an adjustable time delay of from 0 to 600 seconds. The start-up sequence for each device shall include a unique time delay setting when system operation is initiated.

B. Programming software for the PLC shall be provided by the contractor. The programming of the PLC shall be performed by the contractor. All loop testing and debugging shall be performed by the Contractor.

PART 3 - EXECUTION

3.1 PANEL FABRICATION

A. Install each item in accordance with manufacturer's recommendations and in accordance with the Contract Documents.

B. The panel shall be fabricated and UL Listed as an assembly by a qualified panel shop.

3.2 FACTORY TESTING

A. A factory conducted test shall be preformed at the manufacturer’s facility upon the completed fabrication of the PLC system. The factory test shall demonstrate the successful operation of inputs and outputs from the field terminal blocks to the PLC. Provide signal generators and measuring devices as needed for a complete and through test.

B. Hardware and software components of the PLC System shall be thoroughly tested and “burned in” by the SUPPLIER. Inform the OWNER 10 working days prior to the testing of the equipment. The OWNER shall witness these tests before shipment to the site.

C. Panel fabrication drawings shall be updated based on the factory test and a current set of drawings shall be shipped with the panel.

D. The SUPPLIER shall be responsible for all transportation, meals, accommodation, and expenses for the OWNER’s representative witnessing the factory test.

3.3 OWNER TRAINING

A. Provide the services of a factory trained, manufacturer’s representative for instruction of the OWNER’s personnel. The training shall include basic PLC and OIT operation overview, I/O module normal and fault condition indications, and equipment maintenance, troubleshooting, and replacement.

B. The operation and maintenance manuals shall be included as a part of the instruction to the OWNER’s personnel.

END OF SECTION

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SECTION 16720
MAGNETIC FLOW METERS

PART 1 - GENERAL

1.1 THE REQUIREMENT

A. The Contractor shall furnish, test, install, and place into satisfactory operation the magnetic flowmeter systems, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Process Control and Information Systems

B. Instruments, General

PART 2 - PRODUCTS

2.1 MAGNETIC FLOWMETERS

A. Acceptable Manufactures are:
   a. Endress Hauser.
      1) Filter Supplied (2) 16” Flow Meter Model: 5W4C4H-AAELHA0DHA1KGA.
      2) Filter Supplied (1) 10” Backwash Flow Meter Model: 5W4C2F-AAILHA0DHA1KGA.
      3) Filter Supplied (1) 6” Filter-to-waste Meter Model: 5W4C1F-AAILHA0DHA1KGA+AA.
      4) Contractor Supplied (1) 10” Well 12 Flow Meter replacement Model: 5W4C2F-AAILHA0DHA1KGB (0.2% Accuracy)
      5) Contractor Supplied (1) 10” Water Vault Flow Meter Model: 5W4C2F-AAILHA0DHA1KGA
   b. No Substitutions.

B. Process connections shall be flanged, ANSI B16.5, Class 150, raised face.

C. Well Building flow meter shall have local digital display and 4-20 mA HART, pulse/frequency, switch output to the control panel. Transmitter shall be mounted in a NEMA 4X compact aluminum coated enclosure. The meters shall have a hard rubber liner, 316 SS electrodes, and 150 lb flanges. Power supply shall be 110-240VAC/24VAC/DC with ½-inch threaded NPT electrical connection. Flow meter shall be capable of recording forward and reverse instantaneous and totalized flows with ±0.2% accuracy with zero lay length before and after the meter.

D. Magnetic flow meter shall be provided as a system consisting of a flow tube and separate converter/ transmitter complete with interconnecting cables. Converter/transmitter shall be suitable for full-scale flow rates from 3.0 to 30 feet per second. System error shall not exceed the greater of 0.5 percent of rate or 0.1 foot per second. Flow tubes located in lined or non-conductive pipelines shall be provided with grounding spools or swages fabricated from ASTM A312, Type 316 stainless steel. Grounding spools or swages inside diameter shall be 1/16 inch smaller than flow tube inside diameter. Where pipe run size is different from specified flow tube size, uniformly diverging swages with a total angle between walls not exceeding 15 degrees shall be provided. Excitation power requirements shall not exceed 100 volt-amperes.

E. Flow tubes size 0.5 through 6 inches shall be ceramic lined wafer-style ductile-iron body with platinum electrodes. Flow tubes larger than 6 inches shall be cast aluminum full-body flanged construction with 316L stainless steel electrodes. Unless otherwise specified, liner shall be polyurethane.

F. The transmitter shall contain all electronics associated with the magnetic flow meter system. Enclosure shall be NEMA 4 cast aluminum compartment for power, field connections and calibration adjustments separate from digital circuitry. Transmitter shall contain means to calibrate the metering system without use of external calibration units. The transmitter shall contain self-diagnostics and shall be interchangeable with other units of the same type without special re-calibration. Transmitter shall include an integral 3-digit LCD flow indication calibrated in process units. Adjustable dampening shall be provided. Provision for accepting an external contact to force signal output to zero shall be provided. Where pulse frequency output is specified, pulse frequency shall cut out at flows below 2 percent of maximum range. The signal cable between the primary element and transmitter shall be provided by the system manufacturer. A sufficient length of cable shall be provided for installation of a continuous run between the primary element and the transmitter.

G. Remote mounted display/transmitters shall be provided where indicated on the drawings. Flow tubes with integral display/transmitters shall be provided where indicated on the drawings.

H. Magnetic flow meter shall be capable of meeting the specified accuracy requirement with zero lay lengths upstream and downstream from the meter.

PART 3 - EXECUTION

3.1 REQUIREMENTS

END OF SECTION

SECTION 16750

PRESSURE TRANSMITTER

PART 1 - GENERAL

1.0 THE REQUIREMENT

A. The Contractor shall furnish, test, install, and place into satisfactory operation the pressure transmitters, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.1 RELATED WORK SPECIFIED ELSEWHERE

A. Process Control and Information Systems

B. Instruments, General

PART 2 – PRPDUCTS

2.1 PRESSURE TRANSMITTERS

A. Manufacturer

1. Rosemount
2. Dwyer
3. Siemens
4. Emerson
5. Ashcroft
6. Evoqua (USFilter)
7. In Water Valve Vault, Pressure transmitter PT-PSI-105A and PT-PSI-105B shall be 24VCD, 4-20mA, 0-200 psig, Rosemount 2088G3S22A1M4

B. Submersible Level Transmitters

1. Submersible pressure transducer shall be, Dwyer PBLTX, or Evoqua A1000 or equal with Intrinsically Safe barrier for Classified areas. Power supply shall be loop powered 24VDC. Process connection shall be 1/2-inch female NPT flange adapter. Signal output shall be 4 to 20 mA.
2. Transmitter shall be provided with span to match maximum depth of vessel.
3. Transmitter shall be non-clogging and damage resistant to floating solids, suitable for wastewater applications.
4. Transmitter shall be intrinsically safe or loop powered from an intrinsically safe source for classified areas.

C. Gauge Pressure Trasnmitters

1. Power supply shall be 24VDC, powered from PLC panel power supply. Process connection shall be 1/2-inch female NPT flange adapter. Signal output shall be 4 to 20 mA.
2. Pressure transmitter shall be capacitance or resonant-wire type. Unless otherwise specified, wetted parts shall be ASTM A276, type 316 stainless steel. Span shall be adjustable over a 6:1 or greater range. Over range capacity without affecting calibration shall be not less than 200 percent of maximum specified range. Volumetric displacement shall not exceed 0.01 cubic inch over the specified span. Fill fluid unless otherwise specified shall be silicone oil. Adjustable dampening

shall be provided. External zero adjustment shall be provided. Accuracy shall be 0.25 percent of span or better for spans greater than 5 inches water column and 0.5 percent of span or better for spans less than or equal to 5 inches water column.

3. Transmitter shall be provided with the following adjustable range:

Adjustable range of transmitter, water column Span specified in the instrument schedule, water column

Adjustable range of transmitter, water column	Span specified in the instrument schedule, water column
0.5 to 6 inches	0.5 to 5.5 inches
5 to 30 inches	5.5 to 27.5 inches
25 to 150 inches	27.5 to 137.5 inches
125 to 750 inches	137.5 to 750 inches

Higher ranges and spans shall be provided as specified in the instrument schedule. Transmitter for spans less than or equal to 25 psig shall be provided with one 1/2-inch flanged process connection and two 1/4-inch drain/vent ports, one plugged and one provided with bleed valve. Transmitter shall be provided with an evacuated sealed chamber and reference diaphragm shall be provided with a weatherproof, bug proof atmospheric vent. Transmitters for spans greater than 25 psig shall be similar except designed for gage pressure service, and overpressure rating shall be greater than the lesser of 2000 psig and 150 percent of maximum range.

PART 3 - EXECUTION

3.1 REQUIREMENTS

END OF SECTION

SECTION 16751
PROCESS CONTROL STRATEGIES

PART 1 - GENERAL

1.1 THE REQUIREMENT

A. This section includes the process control strategies for this Contract. Together with the process input/output schedule, the equipment specifications (including control strategies for local equipment control panels), and the Drawings, the process control strategies describe the required operation, monitoring, and control of the treatment facilities included in this Contract. The Contractor shall provide all equipment, and services necessary to implement all functions described herein.

B. The Contractor shall be responsible for furnishing functioning systems as described herein. The functional descriptions contain requirements for furnishing and installing labor and materials that may not appear elsewhere in the contract documents.

1.2 GENERAL DESIGN INFORMATION

A. Indicator lights on all MCCs, control panels, starter enclosures, interfaces, etc. shall conform to the following color convention:

Condition	**Color**
Running/Open	Red
Auto	White
Ready/Stopped/Off/Closed	Green
Fail	Amber
Alarm	Amber
Generic Status	Blue or White

B. Running status shall be provided from auxiliary contacts provided with the motor starter. Auto status shall be defined as HOA switch in Auto position. Ready status shall be defined as in remote or auto mode with all interlocks satisfied (no failure conditions present). Stopped and Off status shall be defined as all interlocks satisfied (no failure conditions present), except for no remote or auto mode. Failed status shall be defined as motor overload and/or any other shutdown mode such as over torque, over temperature, low oil pressure, high vibration, etc.

C. A discrepancy failure shall be indicated through the control system for any drive, motor, instrument, etc. that should be running or providing a reading but for which the PLC is not receiving a run status signal or valid reading. An example is a motor which is commanded to run by the control system but is not subsequently detected as running. An adjustable time delay shall be provided for each motor to allow time for the motor to start and satisfy all interlocks.

D. Manual start/stop, open/close, speed/position adjustment, etc., from the Operator work stations shall be provided for all equipment controlled by the control system.

E. Where devices such as temperature, moisture, and/or vibration sensors, over- or under-pressure protection, space heaters, etc. are provided with process equipment and their associated motors under the various sections of Division 11, the Contractor shall provided all required interconnecting wiring between those devices and their associated MCCs, motor starters, VFDs, local control panels, etc.

F. Where setpoints, operating limits, and other control settings are provided by the process control strategies, these settings shall be initial settings only and shall be used for assistance in the initial startup of the plant. All such settings shall be fully adjustable, and based on actual operating conditions, the Contractor shall make all necessary adjustments to provide smooth, stable operation.

G. The control system shall be capable of receiving inputs of initial run-times for existing and proposed equipment. Initial run-time shall not automatically assumed to be zero.

H. All PLC-controlled equipment shall be provided with adjustable start and stop delays in the control logic. Unless otherwise specified, these delays shall be initially set at one minute. Unless otherwise specified, all equipment shall automatically restart after a power failure utilizing adjustable start delay timers in the MCCs and equipment control panels. All PLC control strategies shall be based upon automatic restart after a power failure and shall return to a normal control mode upon restoration of power either by generator or by utility.

I. All setpoint control shall be by PID control algorithms. Where only proportional control is specified, tuning constants shall be used to reduce the integral and derivative functions to zero. All PLC-controlled variable speed equipment shall be provided with individual speed control PID modules in the PLC which shall be cascaded with the overall setpoint PID modules as required. All setpoints, sequence timers, sequence orders, dead bands, PID tuning parameters, PLC delay timers, variable speed operating range limits, and similar control constants shall be accessible and alterable from the Operator work stations.

J. All pumping systems which contain a wetwell shall be provided with a level sensor in the wetwell to automatically shut down the pumps on low level. The low level shutoff shall bypass PLC control (where applicable) and shall be hardwired directly to the pump starter, VFD, MCC or other control circuitry. The Contractor shall supply all required interposing relays and associated circuitry to multiplex the shutdown signal from the single float switch to all pumps at a given wetwell. The low level shutoff shall also be transmitted to the PLC for alarm logging.

K. All setpoints, alarms, etc. based upon an analog input signal or field variable shall be provided with time delays and dead bands to prevent nuisance tripping of controls and alarms.

L. Elapsed run time shall be determined through the run status input to the PLC.

1. Elapsed run time shall be displayed at the SCADA level for each and every motor controlled through the PLC system.

2. Individual elapsed run time accumulation may be reset by the operator after entering a password if the proper security level is associated with said password.

3. Elapsed run time shall be displayed as 99,999.9 hours after which the elapsed

run time registers shall recycle to 0.0 hours.

4. Provisions shall be made to allow the operator to enter a start value for runtime accumulation.

5. Elapsed run time shall be accumulated and stored in PLC registers and not in the SCADA system.

M. PID control algorithms.

1. PID control algorithms shall have operator selectable slew rates for setpoints that will allow the setpoint to slowly ramp to its final value in order to minimize system disturbance.

   a. Individual setpoint slew rates shall be set at a local HMI if available as well as through the SCADA system.

2. Each PID control algorithm shall have a face plate associated with the individual PID control algorithm that shall be displayed at its associated HMI and at the SCADA terminal. Said face plate shall have the following functions:

   a. Display Output, CV.

   b. Display Setpoint, SP.

   c. Display Process Variable, PV.

   d. Allow for operator selection of Automatic or Manual control of Output.

   e. Under manual control of output allow the Operator to enter the desired output value.

   f. Allow for input of the three PID tuning parameters.

N. Programmable settling and proving timers shall be provided in all control sequences for starting and stopping of pumps, in order to let the process settle down before proceeding with any additional control functions.

1. These timers shall be imbedded in the PLC logic, tuned in the field, and listed separately as part of the software submittal and O & M manual.

O. Status indication:

1. All status indication shall match existing status indication in the treatment plant.

P. HMI development shall match existing HMI design requirements in the treatment plant.

Q. Control software and/or hardware shall be so configured and designed as to monitor for loss of analog signal (signal <4 mA), analog signal too large (signal > 20 mA), or rate of signal change too fast (individual rate parameter for each analog input signal to be imbedded in software), when any of these conditions are detected the control system shall alarm this condition, and close the appropriate valve and or stop the appropriate motor in order to prevent the process from running away.

R. The manual control mode shall be completely manual and under the operator control, there shall be no programmed interlocks requiring completion of a previous step before operating a device, unless specifically identified in the individual loop descriptions as occurring in the manual mode.

S. Number of starts shall be accumulated for each motor.

1. The number of starts for the current day shall be moved into a register and held as the previous day's number of starts at 0:01 hours each day.

2. The number of starts for the current day shall be moved entered into the historical data base time and date stamped at 0:01 hours each day.

3. The current day number of starts shall be reset at 0:01 hours each day.

T. Alarm/Fault Indication/Acknowledgement

1. All Alarm/Fault indication and acknowledgement shall match existing plant system.

U. Historization

1. All values shall be historized on the SCADA side consistent with the owner's existing historization strategy. Consult with owner for historization requirements.

b. Power failure.

1. The control system upon sensing a power failure including when switching to Generator shall store, within, the PLC memory the current status of all equipment, i.e. ON or OFF.

2. Upon restoration of power the control system shall then sequence ON all equipment that was running prior to the power failure condition following the same load step sequences as start-up.

3. For Pump Cycling algorithms, the selected stand-by pump shall not be cycled into operation, or an operating pump into stand-by, but shall keep the same cycle selection for all pumps.

c. PLC System Status

1. There shall be indication within the HMI of the PLC system and communications status. The indication and/or alarm shall match existing indication and/or alarm in the treatment plant.

d. Analog device calibration override.

1. Provide a SCADA screen for each and every analog input that allows the Operator to access said analog input to:

   a. Disable the analog input in the PLC control system.

   b. Enter a value for the analog input from the SCADA system to the PLC.

   c. Hold the last analog input value while the actual analog input is disabled.

2. Provide a SCADA screen for each and every analog output that allows the Operator to access said analog input to:

a. Force an output value entered from the SCADA system to the PLC.

b. Hold the last analog output value while the programmed output is disabled.

PART 2 – PRODUCTS

2.1 CONTROL LOOP DESCRIPTIONS

A. CONTROLLER NAMES

There will 6 controllers on site. For the purposes of clarification within this document, they will be referred to by familiar names.

1. The existing PLC controlling the Booster will be referred to as "BOOSTER PLC". The new replacement Booster PLC will be referred to as the "NEW BOOSTER PLC".
2. The existing PLC controlling Well 12 will be referred to as "WELL 12 PLC". The new replacement Well 12 PLC will be referred to as the "NEW WELL 12 PLC".
3. The new Filter system controller provided and programmed by the filter vendor will be referred to as the "FILTER CONTROLLER"
4. The new Hypochlorite system controller in the new filter building that is provided and programmed by the hypochlorite system vendor will be referred to as the "FILTER BUILDING HYPOCHLORITE CONTROLLER"
5. The new Hypochlorite system controller in the new Well 12 building that is provided and programmed by the hypochlorite system vendor will be referred to as the "WELL 12 BUILDING HYPOCHLORITE CONTROLLER"
6. The new PLC in the filter building is for SCADA purposes to coordinate and provide signals to the other controllers in the filter building. It also provides control and alarms for the building valves, and security. It will be referred to as the "FILTER BUILDING PLC".

B. BOOSTER PLC.

1. The Booster PLC will be replaced with a new PLC with a Modicon M340 to match the GHID standard.
2. The programming and I/O will match the existing programming and I/O, like for like.
3. The additional inputs and SCADA functionality for the Booster PLC include:
   a. AI: AT-30-101A FREE CHLORINE. Historize and report Free Chlorine measurements. Coordinate with GHID for High and Low alarm setpoints.
   b. AI: AT-30-101B TOTAL CHLORINE. Historize and report Total Chlorine measurements. Coordinate with GHID for High and Low alarm setpoints.
   c. AI: AT-30-101C WATER PH. Historize and report Water PH measurements. Coordinate with GHID for High and Low alarm setpoints.
   d. AI: AT-30-101D WATER TEMPERATURE. Historize and report Water Temperature. Coordinate with GHID for High and Low alarm setpoints.
   e. {CCD 1} The new ATS that feeds the Well building will alarm if ATS is not in the Normal position.
   f. NEW CODE IN BOOSTER BUILDING PLC SHALL PREVENT ANY BOOSTER PUMP FROM OPERATING WHILE THE BOOSTER BUILDING ATS IS IN GENERATOR POSITION AND THE WELL PUMP IS RUNNING EXCEPT IF THE MANUAL TRANSFER SWITCH IS ON TEMPORARY GENERATOR POSITION. BOTH BOOSTER PUMPS SHALL STOP WHEN THE WELL PUMP COMMAND IS INITIATED. IN OTHER WORDS, THE WELL PUMP IS NOT INHIBITED BY THE OPERATION OF THE BOOSTER PUMPS, BUT THEY CANNOT BOTH BE RUNNING AT THE SAME TIME. CONSIDER ANY RUN-DOWN TIME IF NEEDED TO ENSURE NO POWER IS BEING

DRAWN FROM BOOSTER AND WELL AT THE SAME TIME. THIS NEW CODE SHALL PREVENT BOOSTER PUMP OPERATION IN ALL CASES INCLUDING IN MANUAL. THIS MAY REQUIRE EITHER ADDITIONAL CODE AND/OR ADDITIONAL WIRING TO ACHIEVE.

C. WELL 12 PLC

1. The Well 12 PLC will be replaced with a new PLC with a Modicon M340 to match the GHID standard.
2. The programming and I/O will match the existing programming and I/O, like for like.
3. WATER VAULT

I/O	TYPE	DESCRIPTION
AI	PT	WATER VAULT SYSTEM PRESSURE
AI	FT	TANK FILL FLOW
AI	YI	TANK FILL VALVE POSITION
DI	FQ	TANK FILL FLOW TOTALIZER
DI	NA	WATER VAULT INTRUSION
AO	YC	TANK FILL VALVE

The Tank Fill Valve although an analog device will function as OPEN and CLOSE commands. When open, it fills the tank. When the tank is full, the valve will close completely until the booster pump(s) empty the tank to the minimum fill line for refilling the tank. The analog position feedback will alarm for a difference between command and feedback positions within a bandwidth for a delay. There is provision for future control to use the valve as a pressure control valve. If during testing of the system with all wells it is found that the well VFD response to under/over pressure is not fast enough, then the valve will be programmed to act quickly to pressure changes, with wells attempting in cascade to maintain 50% flow. This will allow the wells to catch up to the valve and place the valve back in a position to act quickly in either direction.

At all times that the wells are available, the pressure transmitter will be used to control the three wells supplying the water vault line. The three wells will regularly alternate a lead, lag, and lag-lag functionality controlling the VFD speed for each well to maintain the pressure setpoint. VFD's have a minimum speed, and then will turn off as needed. Control bands will prevent frequent start/stops.

SCADA will centrally control to the pressure setpoint and determine the desired lead/lag/lag-lag run/stop and speed of each well and communicate commands and setpoints with all three VFD's via SCADA network.

SCADA will monitor run/stop status and speed feedback as well as the health of the communication link in order to make control decisions and alarm mismatches or faults. A well pump in "OFF", miscommunicating, or otherwise shut down will not be considered available for pressure control.

In the event that there is a manual bypass of the site, or other disruption, then each well will return to legacy control via operator input, controlling independently to the system design pressure with their own local pressure transmitter.

4. The additional inputs and SCADA functionality for the Well 12 PLC besides existing I/O and the new Water Vault points include:
   a. AI: Well Pump Outlet Pressure. Shutdown on high pressure.
   b. AI: Pre-Lube Flow. Start permissive, lube flow for long enough time.
   c. AI: Well Speed Status. Alarm on discrepancy between command and status.
   d. DI: Pump in Auto. Alarm when not in Auto.
   e. DI: Well High Discharge Pressure Shutdown. Shutdown on high pressure. Fail safe shutdown.
   f. DI: VFD Fail.
   g. DI: Hypochlorite system alarm.
   h. DI: VFD Motor RTD High Temp Shutdown. Shutdown on high motor temp.
   i. DO: Well Pump Enable. Start Permissives all OK.
   j. DO: Enable Hypo Dosing. When Well running and flow detected, enable Hypo Dosing.
   k. Coordinate with Owner for any additional points.

D. FILTER CONTROLLER
1. The Filter control narrative is included with the Filter system submittal. It operates the filtration, backwash, and cycling of multiple valves per manufacturer control strategies independent of control initiation from operators or other systems except for supervisory control and operator overrides.
2. The Blower is integral with the Filter system and controlled by the Filter controller. It sends a contact to the Blower starter that closes starter contacts across-the-line to both the blower motor, and the cooling fan.
3. WELL RUN COMMAND AND STATUS: Treating the Filter Controller as a black box, it has very few inputs and outputs from the field. Its most common operation for most plants is different then how it will be operated in this plant. In most plants, the system is to request a well run, and when the run status is received, then backwashing operation will be permitted to proceed. However, for this plant, there are many sources of water passing through the filter system. For the purposes of the Filter controller, the well run command will be unconnected and ignored. The well run status will be assumed always on and set as such for the filter system. In the rare case that there may not actually be water available to the filter system, then the filter controller will be manually shut down.
4. WELL SHUTDOWN COMMAND. In most plants, should there be an emergency shutdown or failure of the filter system, then a well shutdown will be issued so that the water is not pushing against a shutdown filter. However, for this plant, with the many sources of water passing through the system, and the requirement for water to continue to be fed through the site, a well shutdown command from the Filter Controller will be interpreted as a requirement to automatically place the filter building valves in a bypass state, and send an alarm.
5. WHEN BUILDING IS IN BYPASS. When the building is placed in bypass mode manually, the filter controller will have its input (likely the Well Run Status input) dropped. The filter system will automatically position its valves for a shutdown case as defined and programmed by the manufacturer.
6. 10-FIT-101-1 RAW WATER FLOW FILTER 1. AI. Historize and report Raw Water flow live into Filter 1. Shared via comms with Filter Building PLC. Note that the Filter Building PLC receives the totalized flow directly.

I/O	TYPE	DESCRIPTION
AI	FT	LIVE FLOW RATE

7. 10-FIT-101-2 RAW WATER FLOW FILTER 2. Totalized PULSE. Historize and report Raw Water flow totalized into Filter 2. Shared via comms with Filter Building PLC. Note that the Filter Building PLC receives the totalized flow directly.

I/O	TYPE	DESCRIPTION
AI	FT	LIVE FLOW RATE

8. 10-FIT-102 BACKWASH WASTE FLOW. Totalized PULSE. Historize and report backwash waste flow totalized. Shared via comms with Filter Building PLC. Note that the Filter Building PLC receives the totalized flow directly.

I/O	TYPE	DESCRIPTION
AI	FT	LIVE FLOW RATE

9. 10-FIT-103 FILTERED TO WASTE FLOW. Totalized PULSE. Historize and report filtered water to waste flow totalized. Shared via comms with Filter Building PLC. Note that the Filter Building PLC receives the totalized flow directly.

I/O	TYPE	DESCRIPTION
AI	FT	LIVE FLOW RATE

E. FILTER BUILDING HYPOCHLORITE CONTROLLER

1. The Filter Building Hypochlorite Control Narrative is to be included with the hypochlorite system submittal and follow the specification "11400 ONSITE HYPOCHLORITE GENERATION SYSTEM". It operates the generation, storage, and dosing of Sodium Hypochlorite to the inlet and to the outlet of the filter building.
2. There are two (2) dosing pumps, one for the inlet, and one for the outlet of the filter building.
3. The Hypochlorite controller contains all I/O and programming necessary to run the entire chlorination train independent of control initiation from operators or other systems except for supervisory control and operator overrides.
4. HYPOCHLRORITE DOSING ENABLE. Part of the Hypochlorite controller operation is to enable dosing and regulate dosing rates. An OFF condition will both request a zero dosing rate, and also drop the dosing enable signal. The dosing pump shall not run if the dosing enable signal is dropped. The off condition shall be programmed per the manufacturers recommendation.
5. PRE-FILTER FLOW INPUT. Dosing rates will be programmed using standard algorithms as recommended by the Manufacturer. Part of that algorithm requires on the flow rate of the pipeline in which chlorine injection is occurring. Because there is not a physical flow meter on the pre-filter pipeline, the dosing rate for the Pre-filter dosing pump will be calculated as the sum of flows in each of the lines drawing from the pre-filter pipeline. The sum is 10-FIT-101-1 plus 10-FIT-101-2. This calculation will be performed in the Filter Building PLC, and an Analog Output from that PLC will send to the Filter Building Hypochlorite Controller an analog signal representing the equivalent flow rate of the pre-filter pipeline. This will allow the Filter Building Hypochlorite Controller to maintain its standard implementation of its dosing algorithm from a single flow input.

6. POST-FILTER FLOW INPUT. Dosing rates will be programmed using standard algorithms as recommended by the Manufacturer. Part of that algorithm requires on the flow rate of the pipeline in which chlorine injection is occurring. Because there is not a physical flow meter on the pre-filter pipeline, the dosing rate for the Post-filter dosing pump will be calculated as the sum of flows into the filter system less the sum of the flows to waste. The sum is plus 10-FIT-101-1 plus 10-FIT-101-2 less 10-FIT-102 less 10-FIT-103. This calculation will be performed in the Filter Building PLC, and an Analog Output from that PLC will send to the Filter Building Hypochlorite Controller an analog signal representing the equivalent flow rate of the pre-filter pipeline. This will allow the Filter Building Hypochlorite Controller to maintain its standard implementation of its dosing algorithm from a single flow input.

F. WELL 12 BUILDING HYPOCHLORITE CONTROLLER

1. The Filter Building Hypochlorite Control Narrative is to be included with the hypochlorite system submittal and follow the specification "11400 ONSITE HYPOCHLORITE GENERATION SYSTEM". It operates the generation, storage, and dosing of Sodium Hypochlorite to the inlet and to the outlet of the filter building.
2. There are two (2) dosing pumps, one is to operate as the duty pump, and one to operate as the stand-by pump.
3. The duty and stand-by pump shall be automatically cycled each month, or by operator request.
4. The Hypochlorite controller contains all I/O and programming necessary to run the entire chlorination train independent of control initiation from operators or other systems except for supervisory control and operator overrides.
5. HYPOCHLRORITE DOSING ENABLE. Part of the Hypochlorite controller operation is to enable dosing and regulate dosing rates. An OFF condition will both request a zero dosing rate, and also drop the dosing enable signal. The dosing pump shall not run if the dosing enable signal is dropped. The off condition shall be programmed per the manufacturers recommendation.
6. FLOW INPUT. Dosing rates will be programmed using standard algorithms as recommended by the Manufacturer. Part of that algorithm requires on the flow rate of the pipeline in which chlorine injection is occurring. This will be sent from an analog output of the PLC replicating the 4-20mA input signal coming from the Well #12 pipeline flowmeter. Rather than using a signal splitter, this allows the PLC to have other conditions including PLC failure and well not running status to remove the flow signal to the dosing pumps. Even a failed flow meter artificially obtaining a flow status would then have the backstop of the additional PLC Logic to detect a no flow state.

G. FILTER BUILDING PLC

1. 10-SV-301 RAW WATER ISOLATION VALVE. The raw water isolation valve is open under normal operation. It is closed during bypass of the filter building. It can be opened or closed manually by commands from the operator interface panel. It closes automatically if the filter shutdown input is asserted.

I/O	TYPE	DESCRIPTION
DO	ZCO	VALVE OPEN COMMAND. FAIL CLOSED.
DI	ZSO	VALVE OPEN STATUS
DI	ZSC	VALVE CLOSED STATUS

INTERNAL	ZSA	ALARM WHEN VALVE STATUS DOES NOT MATCH VALVE COMMAND. DELAY.

2. 10-SV-302 FILTERED WATER ISOLATION VALVE. The filtered water isolation valve is open under normal operation. It is closed during bypass of the filter building. It can be opened or closed manually by commands from the operator interface panel. It closes automatically if the filter shutdown input is asserted.

I/O	TYPE	DESCRIPTION
DO	ZCO	VALVE OPEN COMMAND. FAIL CLOSED.
DI	ZSO	VALVE OPEN STATUS
DI	ZSC	VALVE CLOSED STATUS
INTERNAL	ZSA	ALARM WHEN VALVE STATUS DOES NOT MATCH VALVE COMMAND. DELAY.

3. 10-SV-303 BYPASS VALVE. The bypass valve is closed under normal operation. It is closed during bypass of the filter building. It can be opened or closed manually by commands from the operator interface panel. It closes automatically if the filter shutdown input is asserted.

I/O	TYPE	DESCRIPTION
DO	ZCC	VALVE CLOSE COMMAND. FAIL OPEN.
DI	ZSO	VALVE OPEN STATUS
DI	ZSC	VALVE CLOSED STATUS
INTERNAL	ZSA	ALARM WHEN VALVE STATUS DOES NOT MATCH VALVE COMMAND. DELAY.

4. 10-FIT-101-1 RAW WATER FLOW FILTER 1. Totalized PULSE. Historize and report Raw Water flow totalized into Filter 1. Live value is obtained via communications with SCADA from the Filter Controller.

I/O	TYPE	DESCRIPTION
COMM	FT	LIVE FLOW RATE
PULSE	FQI	TOTALIZED FLOW

5. 10-FIT-101-2 RAW WATER FLOW FILTER 2. Totalized PULSE. Historize and report Raw Water flow totalized into Filter 2. Live value is obtained via communications with SCADA from the Filter Controller.

I/O	TYPE	DESCRIPTION
COMM	FT	LIVE FLOW RATE
PULSE	FQI	TOTALIZED FLOW

6. 10-FIT-102 BACKWASH WASTE FLOW. Totalized PULSE. Historize and report backwash

waste flow totalized. Live value is obtained via communications with SCADA from the Filter Controller.

I/O	TYPE	DESCRIPTION
COMM	FT	LIVE FLOW RATE
PULSE	FQI	TOTALIZED FLOW

7. 10-FIT-103 FILTERED TO WASTE FLOW. Totalized PULSE. Historize and report filtered water to waste flow totalized. Live value is obtained via communications with SCADA from the Filter Controller.

I/O	TYPE	DESCRIPTION
COMM	FT	LIVE FLOW RATE
PULSE	FQI	TOTALIZED FLOW

8. 10-FY-201 CALCULATED RAW WATER INLET FLOW. Calculated and then AO. AO to hypochlorite system to regulate dosing. Raw Water Inlet Flow is the sum plus 10-FIT-101-1 plus 10-FIT-101-2. See also FILTER BUILDING HYPOCHLORITE CONTROLLER above.
9. 10-FY-202 CALCULATED FILTERED WATER OUTLET FLOW. Calculated and then AO. AO to hypochlorite system to regulate dosing. Filtered Water Outlet Flow is the sum plus 10-FIT-101-1 plus 10-FIT-101-2 less 10-FIT-102 less 10-FIT-103. Note that there may be instantaneous cases in which the calculated outlet flow may not represent the actual instantaneous, such as when the filters are filling with raw water. But the totalized flows will eventually align with maximum error equal to a single fill of both tanks. See also FILTER BUILDING HYPOCHLORITE CONTROLLER above.
10. 10-AE-111 FILTERED WATER CHLORINE ANALYZER. Four AI's. Report, historize, hi/lo alarm.

I/O	TYPE	DESCRIPTION
AI	AT	FREE CHLORINE
ALARM	HIGH	HI FREE CHLORINE
ALARM	LOW	LO FREE CHLORINE
AI	AT	TOTAL CHLORINE
ALARM	HIGH	HI TOTAL CHLORINE
ALARM	LOW	LO TOTAL CHLORINE
AI	AT	WATER PH
ALARM	HIGH	HI PH
ALARM	LOW	LO PH
AI	AT	WATER TEMPERATURE
ALARM	HIGH	HI TEMPERATURE
ALARM	LOW	LO TEMPERATURE

11. 10-AE-112 FILTERED WATER AMMONIA ANALYZER. Four AI's. Report, historize, hi/lo alarm.

I/O	TYPE	DESCRIPTION
AI	AT	MONOCHLORAMINE
ALARM	HIGH	HI MONOCHLORAMINE

ALARM	LOW	LO MONOCHLORAMINE
AI	AT	TOTAL AMMONIA
ALARM	HIGH	HI TOTAL AMMONIA
ALARM	LOW	LO TOTAL AMMONIA
AI	AT	FREE AMMONIA
ALARM	HIGH	HI FREE AMMONIA
ALARM	LOW	LO FREE AMMONIA
AI	AT	CL2:NH3 RATIO
ALARM	HIGH	HI CL2:NH3 RATIO
ALARM	LOW	LO CL2:NH3 RATIO

12. 10-AE-113 FILTERED WATER TURBIDITY ANALZYER. One AI. Report, historize, hi alarm.

I/O	**TYPE**	**DESCRIPTION**
AI	AT	TURBIDITY
ALARM	HIGH	HI TURBIDITY

13. 10-TT-101 ROOM TEMPERATURE. One AI. Report, historize, hi/lo alarm.

I/O	**TYPE**	**DESCRIPTION**
AI	TT	BUILDING TEMPERATURE
ALARM	HIGH	HI BLDG TEMP
ALARM	LO	LO BLDG TEMP

14. INTRUSTION ALARM (SECURITY SYSTEM)
    a. All door switches, and the tank hatch shall send an alarm via the security system.

H. NOT CONTROLLED BY PLC
   1. FILTER ROOM VENT FAN controlled by a vent fan controller. Hand-Off-Auto control. Auto Control by high temperature, and on a timer for regular cycling of room air.
   2. HVAC Equipment controlled by thermostat.
   3. ELECTRIC HEATERS controlled by integral thermostat.
   4. LIGHTING controlled by light switches with daylight sensors.
   5. ATS and Generator by integral controls.

END OF SECTION

SECTION 16760

PRESSURE SWITCHES AND SEALS

PART 1 - GENERAL

1.1 THE REQUIREMENT

A. The Contractor shall furnish, test, install, and place into satisfactory operation the pressure switches and seals with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.2 MANUFACTURERS

A. Process Control and information Systems

B. Instruments, General

PART 2 - PRODUCTS

2.1 Pressure Instrumentation

A. Seals

1. All pressure switches and/or transmitters shall be provided with seals.

2. Pressure switches, gages, and/or transmitters and seals shall be assembled and oil filled at the factory prior to shipment. Filling fluid shall be compatible with piping contents and temperature.

3. Pressure switches and/or transducers attached to systems involving chemical solutions, corrosive fluids, or other liquids containing one percent or more of solids, shall be equipped with diaphragm or annular seals whether shown or not on the drawings, or equal protective pressure sensing devices, as follows:

a) Clear process water applications:

1. Type 316 stainless steel for pressures over 15 psi.

2. Elastomer for pressures of 15 psi and below.

3. Type 316 stainless steel nuts and bolts, fill connection and valved flush port size of ¼-inch NPT, capable of disassembly without loss of filler fluid.

4. As manufactured by:

a) Ashcroft Type 101

b) Or prior approved equal.

b) For chemical solutions, sludge, etc., where breakage does not create major shutdown:

1. Seals with PVC body for removable mounting rated at 200 psi.

2. Type 316 stainless steel bolts and nuts

3. ½-inch inlet

4. ¼-inch outlet

5. Liquid-filled with Teflon diaphragm for pressure.

6. Elastomer diaphragm for vacuum service.

c) For sludge, liquids containing solids, pulsating flow:

1. Pressure instrument protectors shall be of the isolation ring type seal with integral instrument removal device.

2. Construction

a. Unit consists of a body, 360 degree flexible elastomeric cylinder with positive O-ring type sealing arrangement, captive fill fluid and two assembly flanges.

b. Includes integral instrument removal device to remove instrumentation without interrupting process flow. The isolation ring I.D. shall match the pipeline I.D. The isolation ring O.D. shall not exceed the I.D. of the piping flange bolt circle. Units are designed to fit 135#, 150# and 300# ANSI piping flanges.

3. Materials

a. Body is 316 Stainless Steel unless otherwise required. Two assembly flanges are 316 S.S. Flexible elastomeric cylinder is Silicone. Captive sensing liquid is glycerin, Silicone or Halocarbon as required for the piped fluid.

4. As manufactured by:

a. Ashcroft Type 80, 81.

b. Prior Approved Equal.

B. Pressure Switches High

1. General:

a. Enclosure NEMA 4X

b. Manual Reset trip on increasing pressure

c. DPDT

d. Actuator Seal: Teflon

e. Each pressure switch shall have visible scale and contact operation.

2. Pressure switches shall have a contact rating of 10 amperes at 125 VAC.

3. Pressure switches shall be snap-action switches and shall be in general-purpose enclosures at indoor installations, or weatherproof enclosures at outdoor installations.

4. Diaphragm seals shall be provided and included at the locations shown.
5. Automatic reset
6. Standard Ranges:
    a. 10” H20, Proof psi 20, Burst psi 35
    b. 30” H20, Proof psi 20, Burst psi 35
    c. 60” H20, Proof psi 20, Burst psi 35
    d. 100” H20, Proof psi 20, Burst psi 35
    e. 150” H20, Proof psi 20, Burst psi 35
    f. 15” H20, Proof psi 500, Burst psi 1000
    g. 30” H20, Proof psi 500, Burst psi 1500
    h. 60” H20, Proof psi 500, Burst psi 1500
    i. 100” H20, Proof psi 1000, Burst psi 3000
    j. 200” H20, Proof psi 1000, Burst psi 3000
    k. 400” H20, Proof psi 2400, Burst psi 3000
    l. 600” H20, Proof psi 2400, Burst psi 3000
7. As manufactured by:
    a. Mercoid.
    b. Or approved equal.

C. Pressure Switches Low
1. Device identifications.
2. General:
    a. Enclosure NEMA 4X
    b. Manual Reset trip on increasing pressure
    c. DPDT
    d. Actuator Seal: Teflon
    e. Each pressure switch shall have visible scale and contact operation.
3. Pressure switches shall have a contact rating of 10 amperes at 125 VAC.
4. Pressure switches shall be snap-action switches and shall be in general-purpose enclosures at indoor installations, or weatherproof enclosures at outdoor installations.
5. Diaphragm seals shall be provided and included at the locations shown.
6. Automatic reset.

7. As manufactured by:

    a. Mercoid.

    b. Or approved equal.

2.2 SPARE PARTS:

A. The CONTRACTOR shall deliver to the OWNER all required spare parts. The spare parts shall not be used as replacement parts during system start-up or the guarantee period.

PART 3 - EXECUTION

3.1 REQUIREMENTS

END OF SECTION

SECTION 16771
LIQUID LEVEL SWITCHES

PART 1 - GENERAL

1.1 THE REQUIREMENT

A. The Contractor shall furnish, test, install, and place into satisfactory operation the liquid level switches with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Process Control and Information Systems

Instruments, General

PART 2 - PRODUCTS

2.1 LIQUID LEVEL SWITCHES

A. Level Switch Tipping Float

1. Device identification.
2. Float actuated switch shall be a dry contact type switch in a hermetically sealed polypropylene casing, suspended on a PVC coated cable.
3. The number of floats per level system shall be as shown.
4. The switch rating shall be at least 10 amps at 120 VAC.
5. Switch set points shall be as shown on the drawings.
6. Mercury switch type capsules are not allowed.
7. As manufactured by:
   a) WE Anderson/Dwyer FSW Series
   b) Or approved equal

B. Room flood monitoring switches

1. Device identification.
2. Stem and mounting shall be 304 Stainless Steel.
3. The float shall be Buna N material.
4. The wetted parts shall be manufactured of Beryllium Copper, Copper Nickel, or Polycarbonate.
5. Dry contact with an electrical rating of 20VA.

6. Operating Temperature of -40 F to 140F.
7. Gems Sensors LS-270 or approved equal.

C. The CONTRACTOR shall deliver to the OWNER all required spare parts. The spare parts shall not be used as replacement parts during system start-up or the guarantee period.

PART 3 - EXECUTION

3.1 REQUIREMENTS

END OF SECTION

SECTION 16772

LEVEL DETECTOR

PART 1 – GENERAL

1.1 THE REQUIREMENT

A. The Contractor shall furnish, test, install, and place into satisfactory operation the Radar level sensor and transmitter systems, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Process Control and Information Systems

Instruments, General

PART 1 - PRODUCTS

2.1 LEVEL DETECTOR/WITH REMOTE DISPLAY/TRANSMITTERS

A. The level detector shall be of the non-contact microprocessor based type for

the continuous measurement of liquid levels.

B. The unit shall be a two piece transmitter/display meter and transducer with interconnecting cables.

C. The transmitter shall store the level profile in the computer memory and moment by moment, analyze the profile to determine the actual liquid level.

D. All program data shall be safeguarded internally in non-volatile EEPROM memory.

E. The transducer shall be encapsulated and shall be capable of:

1. Accuracy of ± 0.25% of range.
2. Range 0.8 to 26.2 feet or the maximum depth of the measured material whichever is greater.
3. Provide for flange mounting, or provide wall mounted mounting bracket as detailed on the drawings.
4. With integral temperature compensation or without temperature factors playing into the level measurements.
5. The unit shall utilize a narrow beam transducer which is rated Class 1 Division 1, explosion proof. The unit shall be provided with factory fabricated lead cable integral to sensor unit and shall extend to the meter unit within the electrical room.

F. The control transmitter shall be in a NEMA 6P enclosure with an integral from panel mounted meter indicating in scaled engineering units.

1. The unit shall provide a 4-20 mA analog output signal directly proportional to level, driven from the PLC and its associated power supplies.
2. The unit shall be capable of displaying by software selection:
   a) Distance to liquid surface from transmitter.
3. The unit shall contain four relays for use as programmable alarm or hard-wired control points.
4. Power requirements shall be 24VDC (fed from a UPS via a power supply.)
5. 4-20 mA output into 750 Ohms at 24 VDC.
6. Selectable damping 1 to 10 m/min.
7. 4 button HMI, wall mounted controller allowing for programming from the panel face, including blanking distances and obstruction blanking.

G. The programming unit shall be incorporated into the body of the instrument.

H. Operating temperature range -40º to 60° C.

I. Mount transducer with non-metallic mounting only.

J. Three wire extended range.

K. As manufactured by:

   1. Siemens Hydroranger 500 with LR100 series radar.

PART 2 - EXECUTION

3.1 <u>REQUIREMENTS</u>

A. Refer to Instruments, General

B. Transducers shall be provided with flange mounting options. Mount to flanged support rigidly attached to wall or concrete square and plumb to building. Sensor shall be mounted to avoid all signal interferences.

END OF SECTION

SECTION 16912

PRESSURE GAUGES

PART 1 - GENERAL

1.1 THE REQUIREMENT

A. The Contractor shall furnish, test, install, and place into satisfactory operation the pressure gauges and seals with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.2 RELATED SPECIFICATION SECTIONS

A. Process Control and information Systems

B. Instruments, General

C. Pressure Switches and Seals

1.3 SUBMITTALS

A. Furnish complete submittals.

B. Product Data

1. Complete manufacturer’s brochures; identify instrument construction, accuracy, ranges, materials and options.

2. Complete instrument data sheets, including catalog number and source for determining catalog number for all gauges and seals.

PART 2 - PRODUCTS

2.1 PRESSURE INSTRUMENTATION

A. Seals

1. All pressure gauges shall be provided with seals.

2. Pressure gauges and seals shall be assembled and oil filled at the factory prior to shipment. Filling fluid shall be compatible with piping contents and temperature.

2.2 PRESSURE GAUGES MANUFACTURED UNITS

A. Pressure, Vacuum, Compound Gauges.

1. General

a. Furnish and install pressure and vacuum gauges as specified; complete, including all fittings, snubbers, connections, gaskets, supports and accessories in the locations shown or specified, in accordance with the Contract Documents.

b. Pressure gauges shall be provided whether or not shown on the plans:

1) On suction and discharge connection to all pumps.

2) On discharge connection from blowers and compressors.

3) On each side of pressure reducing valves.

4) In other locations as shown on the P&IDs and/or mechanical plans.

c. Vacuum gauges shall be provided whether or not shown on the plans:

1) On all supply side educator type chemical feeders.

2) In other locations as shown on the P&IDs and/or mechanical plans.

d. Sleeve pressure gauges

1) Shall be provided where shown on the plans.

2) Pressure shall be sensed by a flexible sleeve contained in a flanged cast iron or steel spool or wafer body, and transmitted to the gauge through a captive fluid.

3) Sleeve shall be of BUNA A and fabricated so as to isolate the body from the process liquid.

4) Gauges shall be calibrated to read in applicable units.

5) Accuracy of ±1% to 150% of the working pressure of the system to which they are connected.

2. Construction

a. Gauges shall be industrial quality type with all Type 316 stainless steel construction.

b. Glycerin filled.

c. All wetted parts shall be stainless steel with a Teflon lined diaphragm..

d. Unless otherwise shown or specified, gauges shall have:

1) A 4 inch minimum dial.

2) ½ inch threaded connection.

3) Type pulsation dampener adapter.

4) A block and bleed valve – ½ inch national pipe thread process connection and bleed/calibrate valve between block valve and outlet port.

e. Gauges shall be calibrated to read in applicable engineering units with the normal operating pressure at 70% of full scale.

f. Accuracy of ±0.5% to 150% of the working pressure or vacuum of the pipe or vessel to which they are connected.

g. All gauges shall be vibration and shock resistant.

3. Seals

a. Gauges attached to systems without particulates shall be equipped with seals.

4. Gauges general as manufactured by:

a. WIKA Industrial Sealgauge®, Type 432.50

b. Or approved equivalent.

5. Gauges sleeve pressure as manufactured by:

a. Red Valve Co., Inc.

b. Ronningen-Petter.

c. Onyx.

d. No Equal.

6. Snubbers as manufactured byL

a. Cajon Co.

b. Weksler Instruments, Corp.

c. Ashcroft.

d. No Equal.

7. Pulsation dampeners as manufactured by:

a. Cajon Co.

b. Weksler Instruments, Corp.

c. Ashcroft.

d. No Equal.

2.3 ACCESSORIES

A. Annular pressure isolator in-line diaphragm type (for pressure gauges).

1. Provide in-line diaphragm pressure sensor for all sewage and sludge piping where shown on the drawings. Contractor shall furnish and install all material required to accommodate the installation of the in-line pressure sensor.

2. The in-line diaphragm pressure sensor shall be provided with flanged ends. The sensor body shall be carbon steel (non-wetted) with Buna N sleeves. All wetted materials shall be suitable for wastewater service.

3. The in-line diaphragm pressure sensor shall be the same diameter as the piping to which it is to be installed.

4. Pressure gauges, switches, and transmitter shall be factory mounted and calibrated and shall conform with Divisions 11, 13, 15 and 16.

B. Product and Manufacturer.

a. Ashcroft Type 80 (wafer).

b. Ashcroft Type 81 (bolt-through, flanged)

c. Or approved equal.

2.4 SOURCE QUALITY CONTROL

A. All instruments and/or representative instruments shall be calibrated to, and in facilities with instruments traceable to the National Bureau of Standards.

1. Provide complete documentation covering the traceability of all calibration instruments.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the complete set of plans, the process fluids, pressures and temperatures and furnish instruments that are compatible with installed process condition.

3.2 PREPARATION

A. Coordinate the installation with all trades to ensure the mechanical system has all necessary appurtenances, weldolets, valves, orientation, etc. for proper installation of the instruments.

3.3 INSTALLATION

A. All instruments shall be installed in strict conformance with the manufacturer's recommendations.

1. It is the CONTRACTOR's responsibility to install all instruments in conformance with manufacturer's recommendations.

2. It is the CONTRACTOR's responsibility to notify the ENGINEER of any installation conditions that may be shown at variance with the manufacturer's recommendations.

B. Install two 2 –valve instrument manifolds for each gauge pressure transmitter.

C. Bolt 3 valve manifolds at non-flange diaphragm type differential pressure transmitters in place of standard flange adapters.

D. Install root valves at process taps except insertion elements.

E. Install gauge valves on process connections to instruments where multiple instruments are connected to one tap or where root valves are not readily accessible.

F. All gauges shall be installed with the face in the vertical position.

G. In strict accordance with the manufacturer's printed instructions.

H. At the locations shown on the drawings, when so shown.

I. Care shall be taken to minimize the effect of water hammer or vibrations on the gauges.

J. In extreme cases, and with the approval of the ENGINEER, gauges may be mounted independently, with flexible connectors.

3.4 FIELD QUALITY CONTROL

A. The Instrumentation and Control Systems Contractor shall calibrate all instruments in the field during the Calibration and Loop Validation Tests as identified.

3.5 ADJUSTING

A. All instruments shall be field verified.

3.6 DEMONSTRATION

A. Performance of all instruments shall be demonstrated to the ENGINEER prior to commissioning.

3.7 PROTECTION

A. All instruments shall be fully protected after installation and before commissioning.

The CONTRACTOR shall replace any instruments damaged prior to commissioning.

1. The ENGINEER shall be the sole party responsible for determining the corrective measures.

END OF SECTION

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SECTION 16913
CONTROL DEVICES

PART 1 - GENERAL

1.1 SCOPE

A. This section sets forth the general specification and requirements for the control devices that shall be provided with control panels, motor starters, and other enclosures in order to assemble a complete and operable control, alarm, or indicating system.

B. The SUPPLIER shall coordinate the installation of items specified herein as required to ensure the complete and proper interfacing of all the components and systems.

1.2 APPLICABLE SECTIONS

A. The General Conditions, Supplementary General Conditions, Special Conditions, alternates and Addenda, applicable drawings and the technical specification herein shall apply to work under this Section.

1.3 APPLICABLE REFERENCES

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (1985; Incl. Rev. I and 2; ICS-6) Enclosures for Electrical Equipment

NEMA ICS 1 (1988) General Standards for Industrial Controls and Systems

UNDERWRITERS LABORATORIES, Inc. (UL)

UL 50 Enclosures for Electrical Equipment

UL 508 Industrial Control Equipment

1.4 SUBMITTALS

A. Provide complete submittal information for the “control devices”.

B. Comply with the following requirements:

1. Submit certified dimensional drawings and manufacturer’s data sheets for each size and type of device specified herein to be utilized. Data sheets are to be highlighted to define the specific materials of construction and features specified herein along with detailed manufacturer’s model number.

2. Submit instruction bulletins for each type of control device. The instruction bulletins shall include installation instructions, wiring diagrams, power requirements, maintenance instructions, calibration instructions, and any other details of a specialized nature to the devices furnished.

C. Additional submittal requirements:

1. Circuit Breakers and/or fuses:

a. Provide a complete schedule showing load and rating of circuit breakers and/or fuses.

2. Control power transformers and/or power supplies:

   a. Provide complete sizing calculations in accordance with the requirements identified herein.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturers have been indicated for various specified devices to establish the standard of quality and performance of the equipment to be supplied.

B. Devices of a given type shall be of the same model, class, or rating, have the same general appearance, and be from the same manufacturer.

2.2 GENERAL REQUIREMENTS

A. Analog measurements and control signals shall:

   1. Be electrical as indicated herein, and shall vary in direct linear proportion to the measured variable, except as noted.
   2. Electrical signals outside control panels shall be 4 to 20 mA DC, except as noted.
   3. Signals within enclosures may be 1 to 5 VDC, or 0-10 VDC.
   4. Dropping resistors shall be installed at all field side terminations in the control panels to ensure loop integrity.

B. Control panels provided with integral power supplies and control power transformers shall be configured to match the voltage and current requirements of the loads.

C. Each control loop or instrument shall have an individual circuit breaker or fuse within its respective control panel and clearly identified for function.

D. Each PLC output shall have its own individual fuse external of the I/O card, with blown fused indication.

   1. Size external fuse to open before any I/O card mounted fuses.

F. Signal isolators, Signal Converters, and Power Supplies:

   1. Signal isolators shall be furnished and installed in each measurement and control loop, wherever required:
      a. To ensure adjacent component impedance match.
      b. Where feedback paths may be generated.
      c. To maintain loop integrity when the removal of a component of a loop is required.
   2. Signal converters shall be included where required to resolve any signal level or signal type incompatibilities.
   3. Power supplies shall be included, as required by the device manufacturers' load characteristics, to ensure sufficient power to each loop component.

2.3 CONTROL DEVICES

A. Signal Isolators and Converters.

1. Signal isolators shall have complete isolation of input, output and power input.
    a. Signal input shall be 4-20 mA into 50 ohms, maximum.
    b. Signal output shall be 4-20 mA into 1000 ohms, minimum.
    c. Power input shall be 120 VAC, 60 Hz or 24 VDC.
    d. Span and zero shall be adjustable.
    e. Accuracy shall be ±1 percent of span.
    f. Units shall be surface or DIN rail mounted.
2. Signal Converters
    a. Signal inputs of 1-5 V, 0-10 V, ect.
    b. Signal output shall be 4-20 mA into 1000 ohms, minimum.
    c. Power input shall be 120 VAC, 60 Hz or 24 VDC.
    d. Span and zero shall be adjustable.
    e. Accuracy shall be ±1 percent of span.
    f. Units shall be surface or DIN rail mounted.
3. Acceptable manufacturers:
    a. Accromag.
    b. AGM Electronics Model TA-4000.
    c. Or approved equal.

B. Relays

1. General Purpose Relays:
    a. General purpose relays shall be plug-in type.
    b. Contacts rated 10 amperes at 120 volts AC.
    c. With LED indication when engergized.
    d. Quantity and type of contacts shall be as shown on the Plans or as needed for system compatibility.
    e. Each relay shall be enclosed in a clear plastic heat and shock resistance dust cover.
    f. Sockets for relays shall have screw type terminals.
    g. Provide transient surge protection across the coil of each relay.
    h. Relays shall be:
        1) Potter and Brumfield Type KRP or KUP.
        2) IDEC.
        3) Square D Type K.
        4) Allen Bradley.

5) Or approved equal.

2. Slave and Interposing Relays:

a. Additional slave relays shall be provided when the number or type of contacts shown exceeds the contact capacity of the specified relays and timers.

b. Additional relays shall be provided when higher contact rating is required in order to interface with starter circuits or other equipment.

c. Shall be provided to compensate for voltage drop due to long wire runs.

d. The slave and interposing relays shall be as the general purpose relays.

e. Provide transient surge protection across the coil of each relay.

3. Time Delay Relays

a. Time delay relays shall be pneumatic on-delay or off-delay type.

b. Contacts shall be rated 10-amperes at 120 VAC.

c. Units shall be including adjustable dial with graduated scale covering the time range in each case.

d. Provide transient surge protection across the coil of each relay.

e. As manufactured by Agastat, Series 7000.

C. Manual Operators and Interface Devices - Unclassified Areas

1. General Requirements

a. NEMA Type 13 Oil tight.

b. With synthetic rubber gasket.

c. Heavy duty.

d. Industrial grade full size 1 – 13/64” diameter.

2. Pushbutton Units:

a. Contacts rated:

1) NEMA A600.

2) 600 VAC maximum.

b. Color Code:

1) Red - Stop

2) Green - Start

3) Orange - Open

4) Blue - Closed

c. As manufactured by:

1) Allen Bradley 800T.

2) Square D Type K.

3) Cutler-Hammer 10250T Series.

d. Furnish one spare normally open and normally closed contact with each switch.

3. Selector Switches:

a. Contacts rated:

1) NEMA A600.

2) 600 VAC maximum.

b. As manufactured by:

1) Allen Bradley 800T.

2) Square D Type K.

3) Cutler-Hammer 10250T Series.

c. Furnish one spare normally open and normally closed contact with each switch.

4. Pilot Lights:

a. Transformer type LED pilot lights.

b. 120 VAC.

c. Push to Test type.

d. As manufactured by:

1) Allen Bradley.

2) Square D Type K.

3) Cutler-Hammer 10250T Series.

D. Manual Operators and Interface Devices - Corrosive Areas

1. General Requirements:

a. NEMA 4X corrosion resistant.

b. Exterior parts to be made of high impact strength fiberglass reinforced polyester or other corrosion resistant materials.

c. Incorporating an internal neoprene boot which completely encloses all internal parts.

e. Industrial grade full-size 1 – 13/64” diameter.

2. Pushbutton

a. Having an integral wiping gasket around the pushbutton that cleans the wall of the pushbutton guard of any foreign material accumulation as the button is operated.

b. Contacts rated:

1)NEMA A600.

2)600 VAC maximum.

c. Color code:

1) Red - Stop

2) Green - Start

3) Orange - Open

4) Blue - Closed

d. As manufactured by:

1) Allen Bradley NEMA 4, 4X – 800H.

2) Crouse Hinds NPB1211.

3) Cutler-Hammer E34 Series.

4) Square D Type SK.

3. Selector Switches:

a. Contacts rated:

1) NEMA A600.

2) 600 VAC maximum.

b. As manufactured by:

1) Allen Bradley NEMA 4, 4X-800H.

2) Crouse Hinds NW 12221.

3) Crouse Hinds NSW 12321.

4) Cutler-Hammer E34 Series.

5) Square D Type SK.

c. Furnish one spare normally open and normally closed contact with each switch.

4. Pilot lights:

a. Transformer type LED pilot lights.

b. 120 VAC.

c. Push to test.

d. Light colors shall be as identified on the Plans.

e. As manufactured by:

1) Allen Bradley NEMA 4, 4X-800H.

2) Crouse Hinds NW 12221.

3) Crouse Hinds NSW 12321.

4) Cutler-Hammer E34 Series.

5) Square D Type SK.

E. Terminal Blocks

1. Din rail mounted.

2. Terminal to be of the tubular screw type with pressure plate to minimize the possibility of breaking wire strands during tightening.

3. Recessed terminal hardware to minimize the possibility of contact with current carrying parts.

4. Molded of high dielectric material.

5. Minimum rating 600 VAC, 30 amp.

6. External connections to and from all control panel must be via terminal blocks, including power, control, alarm, instrumentation, monitoring, and solenoid circuits.

7. Individual terminals and terminal blocks shall be marked in a permanent manner with printed identification.

8. As manufactured by:

    a. Entrelec M 4/6

    b. Phoenix Contact UK 5 N

    c. Or approved equal

F. Conductors within Control Panels

1. Single conductors shall be as follows:

    a. Material: Soft annealed coated copper per ASTMB33 or B189.

    b. Standard: ICEA S-19-81.

    c. Stranded Wire - Class B.

    d. Insulation and Coverings:

        1) Thickness: Per ICEA.

        2) Material:

            a) No. 8 and Smaller: Type XHHW single conductor, copper power cable, moisture resistant, flame retardant thermoplastic insulation, 600 volt, 75 °C.

            b) No. 6 and larger: Type XHHW-2 single conductor, copper power cable, heat and moisture resistant, flame retardant, thermoplastic insulation, 600 volt, 75°C.

    e. No. 14 AWG minimum, shall be used for field control circuits, unless otherwise noted.

    f. No. 16 AWG minimum, Type MTW shall be used for all PLC I/O connections within the panel; between I/O device and field wiring terminal blocks.

2. Instrumentation Cable (Shielded Twisted Pair STP):

    a. Minimum conductor size 18 AWG.

    b. Stranded and tinned copper conductors.

    c. Polyethylene conductor insulated.

    d. Foil aluminum-polyester shield – 100% shielding.

e. Minimum 18 AWG, stranded, tinned, copper drain wire.

f. PVC outer jacket.

g. UL Listed, TC rated.

h. 600 volt insulation level.

G. Wire markers:

1. Conductors within the control panel are to be permanently marked with wire numbers at each end.

2. Wire numbers are to correspond to the wire numbers indicated on the submittal drawings and are to correspond to the terminal block number to which they are attached in the control panel.

3. Markers shall be heat shrinkable tubing, imprinted type wire markers.

4. Manufacturers:

   a. 3M.

   b. Thomas & Betts.

   c. Panduit.

H. Nameplates:

1. Nameplates: Engraved three-layer laminated plastic, white letters on black background.

2. Control components within the control panel shall have nameplates secured with stainless steel screws. Nameplates cannot be attached to the covers of the panel wireways.

3. The enclosure and components on the front cover or interior swing out panels shall be identified by nameplates.

   a. Use standard manufacturer engraved nameplates for all pushbuttons, and selector switches only if color matches that specified for engraved nameplates. If not, then furnish nameplates to match colors as specified herein.

   b. Use engraved plastic laminated nameplates for all other devices, displays, keypads, and annunciator LED's.

   c. For NEMA 12, 4, and 4X enclosures, use an epoxy based adhesive to affix nameplates to enclosure cover.

4. A nameplate shall be provided for each signal transducer, signal converter, signal isolator, power supply, relay, terminal strips, and the like mounted inside the panel. The nameplate nomenclature shall match the component names identified in the submittal drawings.

5. Lettering, styles, abbreviations and sizes shall be in conformance with ISA-RP-60.6 (1984) with an intended viewing distance of 3 to 6 feet for external nameplates and 1 to 2 feet for internal nameplates.

I. Control Circuit Breakers:

1. Each 120 VAC control circuit, instrument, or loop shall be powered from an individual control circuit breaker.
2. Din rail mounted using the same DIN rail as used for the terminal blocks.
3. Manual ON-OFF Switch.
4. Rated 240 VAC.
5. Rated 2000 AIC.
6. Current ratings as needed load served.
7. Provide complete nameplate identifying each circuit.
8. As manufactured by:
   a. ABB
   b. Phoenix Contact
   c. Entrelec
   d. Square D

J. Fused Terminals:
   1. Isolate all PLC Digital Outputs with fuses.
   2. Isolate all PLC Digital Inputs with fuses.
   3. Isolate all PLC Analog Inputs and Outputs with fuses.
   4. Coordinate fuse size to be as recommended by the manufacturers. For PLCs, the fuse size to be below internal output protection of the PLC output module.
   5. Fuses to be terminal block mounted.
   6. Furnish nameplate identifying each fused terminal.
   7. As manufactured by:
      a. Entrelec
      b. Phoenix Contact
      c. Or approved equal

K. Field / Remote Connections:
   1. Field/remote connections shall be made at terminal blocks within the panel.
   2. Furnish an individual terminal block space for each wire.
      a. Two wires on one terminal block will not be allowed.
   3. Furnish an empty wire channel on the backpanel adjacent to the field/remote terminal block strip to be used to route the field/remote wires to the connection terminal blocks.
   4. Provide spare terminal blocks as specified herein.

L. Control Voltages:
   1. Control voltage shall be supplied via control circuit breakers in the panel.

2. Control power shall be sourced from the 120V power supplied to the panel, unless otherwise noted in the Plans.

3. AC control voltages other than that supplied shall be transformed via a control power transformer within the panel. DC control voltages shall be supplied by AC to DC power supplies, specified herein.

M. Control Power Transformers:

1. Low impedance type.

2. The control power transformers shall have fused over current protection on both the primary and secondary sides of the transformer.

3. Use actual coil power factors in calculating the VA rating of the transformer. Use a power factor of 35% if power factor of coils is unavailable.

4. Determine the continuous VA rating of the transformer based on maximum sealed VA load current from the coils of the starters, relays, and pilot lights. Maximum inrush current shall be calculated based on the maximum inrush of devices that can be energized at one time plus the load presented by the devices already energized, and the actual power factor of the loads. This maximum inrush current must not cause the secondary voltage of the transformer to fall below 85% of rated voltage when the primary voltage has been reduced to 90% of rated voltage. Based on these calculations then actual transformer size shall be the calculated value times 1.5.

N. Transient / Surge Protection

1. Data and Signal Line Protectors to be used on each and every analog input or output, and on each and every data and signal line external connection point:

a. Provide electronic circuits and components from damaging surge voltage and currents.

b. Provide protection of signal and data lines associated with computer, data, communications, instrumentation, broadcasting, and industrial control interfaces.

c. Shall be used directly with EIA standard interfaces:

1) RS-232

2) RS-422

3) RS-423

4) RS-485

5) 4-20 mA instrumentation loops.

d. Repeatedly provide protection against surge currents in excess of 10,000 Amps.

e. DIN rail mounted.

f. Cable shields shall be passed through and may be either grounded or not grounded at the protector.

g. System:

1) Heavy duty multi-staged protectors.

2) Solid state stage intercepts the leading edge of the surge with sub-nanosecond response time.

3) Within micro-seconds, a 3-pole common chambered gas tube capable of handling 20,000 ampere lightning current operates and crowbars the surge to ground.

4) The protector remains in the crowbar state until the surge has passed and line voltages return to safe levels.

h. Location:

1) Place at each end of a signal line, data line, or current loop.

2) In the case of daisy chain configuration, such as RS-485, protectors shall be placed at each node.

i. Electrical Characteristics:

1) Surge Life:

a) Greater than 1000 operations with 200 Amps, 10 x 100 µsec.

b) Greater than 10 operations with 10,000 Amps, 8 x 20 µsec.

2) Leakage current at rate line to ground voltage < 10 µAmps.

3) Signal/Data attenuation at maximum data rate 3 db with 600 terminations.

4) Operating temperature -40°C to +60°C.

j. As manufactured by:

1) Joslyn:

a) For differential signals, such as RS-422 or RS-485, and current loops – Model 1820.

b) For high frequency differential signals and current loops – Model 1821.

c) For line to ground protection, two separate circuits, and ground referenced signals (RS-232) and 4-20 mA loops where the return wire is grounded at the protector – Model 1810.

d) For high frequency line to ground protection, two separate circuits, and ground referenced signals (RS-232) and 4-20 mA loops where the return wire is grounded at the protector – Model 1811.

2. Protection from inductive spikes within the control panel.

a. Provide surge protection across all inductive coils for control relays, starters, solenoids, etc.

O. Power Supplies: Power supplies shall convert 120 VAC ±10% to 24 volt DC or other DC voltages as necessary.

1. Power supplies shall have an excess rated capacity of 40 percent or be rated 100 watt minimum.

2. The failure of a power supply shall be annunciated at the control panel and repeated to the SCADA system through a connection to PLC.

3. Output regulation shall be accurate within ±0.05% for a 10% line change or a 50% load change and shall include remote voltage sensing.

4. The power supply shall be rated for temperatures of 32 to 122 degrees F and shall be UL recognized.

5. Power supplies shall have fully isolated primary and secondary coils which shall be surrounded by an insulating enclosure which shall also provide mechanical isolation.

6. All power supplies shall be designed and configured as fully redundant systems so that the failure of one power supply will automatically transfer to the other power supply with no interruption in power.

   a. The power supply failure shall supply a dry contact for connection to a PLC input for an alarm indication.

7. As manufactured by:

   a. Power One W Series.

   b. Phoenix Contact Quint Series.

   c. IDEC Slim Line.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Conform to all application provisions of the NEMA and UL standards, NEC and local, state, and federal codes when fabricating the equipment.

B. Install each item in accordance with manufacturer's recommendations and in accordance with the Contract Documents. Locate devices, including accessories, where they shall be accessible from grade, except as shown otherwise.

C. Mount components in accordance with the installation details as prepared by the manufacturers.

D. Mount equipment so that each device is rigidly supported, level and plumb, and in such a manner as to provide accessibility; protection from damage; isolation from heat, shock, and vibration; and freedom from interference with other equipment within the panel.

E. Items, components, devices, and accessories shall be mounted and anchored using stainless-steel hardware, unless otherwise noted.

3.2 SPARES

A. Unused inputs and outputs from the PLC shall be wired to field terminal blocks and identified.

B. Furnish one spare normally open and one spare normally closed dry contact for each push-button, selector switch, relay, etc.

C. Furnish ten spare fuses for each type of fuse in the panel.

D. Furnish 15 spare terminal blocks or 20% whichever is greater.

E. Furnish five spare relays for each type used in the panel.

F. Spare contacts of relays, switches, etc., shall be internally wired to terminal blocks.

END OF SECTION

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SECTION 16913.16
CHLORINE ANALYZER

PART 1 GENERAL

1.1 Section includes

A. Potentiostatic chlorine analyzer for continuous measurement free chlorine in aqueous solutions.

1.2 Measurement Procedures

A. The method of measuring free chlorine will be with a three-electrode potentiostatic sensor immersed into an electrolytic medium with a gold electrodes, selective to free chlorine, separating it from the sample.
B. pH and Temperature correction
   1. pH compensation by included 0-14 pH measurement
   2. Temperature compensation by Pt-100 temperature measurment

1.3 Alternates

A. Other methods of chlorine measurement, such as a two-electrode amperometric and amperometric requiring a flexible replaceable membrane plus electrolyte are not acceptable.

1.4 System Description

A. Performance Requirements
   1. Measurement range selectable: 0-1000 ppb, 0-5 ppm, 0-10 ppm, and 0-20 ppm chlorine for free chlorine.
   2. Free Chlorine
      a. Low Limit of Detection (LOD): 40 ppb (0.04 ppm) or better
      b. Response time: ~21s for 90% change (T_{90}) (At a stable T and pH)
      c. Interference: Chlorine Dioxide, and Ozone
   3. Drift: <10% with regular calibration (calibration will be weekly to quarterly depending on the application, given stable sample temperature and pH of water sample)
   4. Specificity/Selectivity: free chlorine
   5. Calibration method: A one point
   6. Verification procedure: One-point process calibration (slope) against a standard reference method.
   7. Measurement Ranges:
      a. Free chlorine: 0-10mg/L
      b. Temp: 0-50degC (32-122F)
      c. pH: 0-14
      d. Total chlorine: 0-10mg/L

1.5 Certifications (when connected to a Kuntze Krypton Multi system):

A. CE-Symbol: The product meets the requirements of the Harmonized European standards and complies with the legal requirements of the EC directives

B. EMC: EN 61000 6-1 (3) EN 61000 6-2 (4) EN 61326-1

C. Rating: Front IP54; IP65

1.6 Environmental Requirements

A. Operational Criteria
   1. Operating temperature: -5 to 50 °C (23 to 122 °F)
   2. Relative humidity: 0-95%, non condensing

B. Sample Requirements
   1. Maximum back pressure the chlorine sensor can manage without failure:
      a. 6.0 bar (87 psi)
   2. Temperature: 0 to 50 °C (32 to 122 °F)
   3. Temperature compensation range: 0 to 50 °C (32 to 122 °F)
   4. Flow: 35 – 400 L/hr (Instrument Controlled at 30 L/hr)
   5. Pressure: 6.0 bar (87 psi)

C. Storage Requirements
   1. Chlorine sensors: 0 to 30°C (32 to 86°F)

1.7 Warranty

A. The product includes a one-year warranty from the date of shipment.

1.8 Maintenance Service

A. Scheduled maintenance:
   1. Calibration by comparison with lab method: every 1 month or as necessary
   2. Automated cleaning can be programmed via ASR

B. Unscheduled maintenance
   1. Cleaning as needed based on environmental conditions.
   2. Working electrode tip scrubbing with wet paper towel and granular cleaning detergent.

PART 2 PRODUCTS

2.1 Manufacturer

A. Kuntze Instruments, Meerbusch, Germany
   1. Model Krypton Multi Reagentless Free Chlorine Analyzer

2.2 Manufactured Unit

A. The Kuntze Krypton Multi analyzer consists of:

1. Three Electrode Potentiostatic sensor that employs a two gold measuring electrodes.
2. Argon® StabiFlow Assembly that incorporates an inlet and outlet with stop cocks, sampling point, holder for FCL sensor, flow control, filter, check valve multisensor for flow monitoring and temperature
3. Neon Multi controller with five 4-20mA outputs, four control relays, four alarm relays.
4. Pre-assembled PVC panel mount

2.3 Equipment

A. The Zirkon® DIS FCL sensor work with Kuntze Neon controllers. (Specific controller specifications can be found in the associated sensor CSI specifications)
B. The potentiostatic cell of the sensor consists of:
   1. Two gold electrodes
   2. Silver/silver chloride/Tepox-Gel reference electrode
C. Wetted materials as follows:
   1. Chlorine Measuring Cell: Acrylic
   2. Chlorine Sensor Body: Glass
   3. Chlorine Sensor Flow Cell: Acrylic
   4. Optional pH Sensor Flow Cell: Acrylic
D. The chlorine sensor automatically compensates for temperature utilizing an external temperature sensor.
E. The panel assembly includes a flow control and monitoring.

2.4 Components

A. Standard equipment:
   1. PVC Mounting Panel
   2. Chlorine Sensor with gold electrodes
   3. Stabiflow Assembly with temperature sensor/flow monitor
   4. User Manual
B. Dimensions
   1. Sensor
      a. Length: 5.94 in. (151mm)
      b. Diameter: 0.47 in. (12 mm)
   2. Panel
      a. Length: 19.7 in. (500 mm)
      b. Width: 15.8 in. (400 mm)
      c. Depth: 6.3 in. (160 mm)

C. Weight
   1. Complete panel: approximately 14 lbs. (6.4 kg)

PART 3 EXECUTION

3.1 Preparation

A. Clearances
   1. The pre-assembled analyzer panel must be mounted to allow clearance for sensor removal and routine maintenance.
B. Mounting
   1. Wall or panel mounted
C. Sample Inlet (Metric Fittings)
   1. Metric Fittings
      a. Tube Connector DN 6/8 ¼”
D. Sample Outlet Metric (Fittings)
   1. Metric Fittings
      a. Tube Connector DR 6/8 ¼”

3.2 Installation

A. Contractor will install the analyzer in strict accordance with the manufacturer’s instructions and recommendation.
B. Manufacturer’s representative will include a half-day of start-up service by a factory-trained technician, if requested.
   1. Contractor will schedule a date and time for start-up.
   2. Contractor will require the following people to be present during the start-up procedure.
      a. General contractor
      b. Electrical contractor
      c. Kuntze factory trained representative
      d. Owner’s personnel
      e. Engineer

3.3 Manufacturer’s Service and Start-Up

A. Contractor will include the manufacturer’s services to perform start-up on instrument to include basic operational training and certification of performance of the instrument.
B. Contractor will include a manufacturer’s Service Agreement that covers all the manufacturer’s recommended preventative maintenance, regularly scheduled calibration and any necessary repairs beginning from the time of equipment startup through to end user acceptance / plant turnover and the first 12 months of end-user operation post turnover.

END OF SECTION

SECTION 16913.19

Turbidity Analyzer

PART 1 GENERAL

1.1 Section includes:

A. Instrument for monitoring turbidity in water accordance/compliance with DIN EN ISO 7027.

1.2 Measurement Procedures

A. The method of measuring turbidity will be nephelometric using pulse scattered infrared light at 860nm at a 90° angle in accordance with/compliance with DIN EN ISO 7027.

1.3 Alternates

A. Other methods of turbidity measurement including those that require a sample cell, those with incandescent light sources, or turbidimeters used for EPA reporting are not acceptable.

1.4 System Description

A. Performance Requirements
   1. Range
      a. 0.0001 to 1000 FNU (1 FNU = 1 NTU)
   2. Resolution
      a. 0.0001 to 0.9999 / 1.000 to 9.999 / 10.00 to 99.99 / 100 to 1000 FNU (NTU)
   3. Precision
      a. +0.008 FNU or +1% of reading (0 to 10 FNU)
   4. Repeatability
      a. +0.003 FNU or +5% of reading (0 to 2 FNU)
   5. Response time
      a. 1 to 60 seconds (user adjustable)

1.5 Certifications

A. EMC: CE compliant for conducted and radiated emissions CISPR 11 (Class A limits), EMC Immunity EN 61326-1 (Industrial limits) when connected to an sc controller.

B. Safety: General Purpose UL/CSA 61010-1 with cETLus safety mark when connected to an sc controller

C. Australian C-TICK and Korean KC Markings when connected to an sc controller.

D. IP 65 Enclosure Rating

1.6 Environmental Requirements

A. Operational Criteria
   1. Operating Temperature
      a. 36 to 104 °F (2 to 40°C)
   2. Sample Temperature
      a. 122 °F (50 °C) maximum
   3. Sample Pressure
      a. 87 psi at 68°F (6 bar at 20°C)
   4. Sample flow rate
      a. Minimum: 0.2 L/min
      b. Maximum: 1L/min

5. Sample Salt Content (for *seawater* version ONLY)
    a. Tested up to 65 g/L

1.7 Warranty

A. The sensor includes a one-year warranty from the date of shipment.

1.8 Maintenance Service

A. Scheduled Maintenance
    1. Every 1200 Cycles
        a. Replace wiper profile (only on *plus* and *seawater* versions)
    2. Every Two Years
        a. Replace desiccant
        b. Monitor test equipment with CVM Dry Calibration
B. Unscheduled Maintenance
    1. Clean measuring chamber
        a. Dependent on substances contained in the water
    2. Check Zero Point
        a. Dependent on substances contained in the water
    3. Check Gradient
        a. At least once per year

PART 2 PRODUCTS

2.1 Manufacturer

A. Hach-Lange GmbH, Berlin, Germany
    1. Ultraturb sc Basic/Plus/Seawater Turbidimeter
        a. LPV415.52.10002

2.2 Manufactured Unit

A. The Ultraturb sc Turbidimeter consists of an 860nm LED light source, detection system, and internal light trap. Sample chamber wiper available for *plus* and *seawater* versions.

2.3 Equipment

A. The Ultraturb sc functions when attached to Hach model sc200 controller only. (Additional specifications can be found in the CSI documents for these particular controllers)
B. The Ultraturb sc turbidimeter operates continuously.
C. The Ultraturb sc turbidimeter provides user selectable bubble rejection, alarm and controller output hold, and self-test diagnostics.
D. The sc200 controller is capable of functioning with one or two Ultraturb sc turbidimeters
E. Wetted materials as follows:
    1. Measuring window:
        a. Quartz
    2. Measuring Chamber:
        a. Noryl GFN2
    3. Wiper axle:
        a. Stainless Steel 1.4571
    4. Wiper arm (*seawater* version only):
        a. Titanium Alloy
    5. Wiper profile

a. Silicone

2.4 Components

A. Standard Equipment
   1. Ultraturb sc sensor with appropriate cable length
   2. User Manual
   3. Factory Test Certificate
   4. Accessory Set
   5. Wiper Set (only for *pfus* and *seawater* versions)

B. Dimensions: 9.9 x 9.4 x 4.3 in. (250 x 240 x 110mm)

C. Weight: 3.3 lbs (1.5 kg)

2.5 Optional Accessories

A. Certified Verification Module Dry Standard, 0.6 NTU (HACH model # LZV414.00.00000)

B. Extension Cable

C. Formazin Turbidity Standard, 4000 NTU, 500 mL (HACH Model #246149). Contractor shall dilute to 10 NTU for calibration during startup.

D. SC200 Universal Controller, Part Number LXV404.99.00502
   1. Power Option: 120VAC
   2. Communication Capabilities: Serial communication not required.
   3. Mounting Option: Surface mount

PART 3 EXECUTION

3.1 Preparation

1. Mounting
   a. Wall mount only
2. Sample inlet
   a. 13 mm ID tubing
3. Drain
   a. 13 mm ID tubing

3.2 Installation

A. Contractor will install the analyzer in strict accordance with the manufacturer's instructions and recommendation.

B. Manufacturer's representative will include a half-day of start-up service by a factory-trained technician, if requested.
   1. Contractor will schedule a date and time for start-up.
   2. Contractor will require the following people to be present during the start-up procedure.
      a. General contractor
      b. Electrical contractor
      c. Hach Company factory trained representative
      d. Owner's personnel
      e. Engineer

3.3 Manufacturer's Service and Start-Up

A. Contractor will include the manufacturer's services to perform start-up on instrument to include basic operational training and certification of performance of the instrument.

B. Contractor will include a manufacturer's Service Agreement that covers all the manufacturer's recommended preventative maintenance, regularly scheduled calibration and any necessary repairs beginning from the time of equipment startup through to end user acceptance / plant turnover and the first 12 months of end-user operation post turnover.

C. Items A and B are to be performed by manufacturer's factory-trained service personnel. Field service and factory repair by personnel not employed by the manufacturer is not allowed.

D. Use of manufacturer's service parts and reagents is required. Third-party parts and reagents are not approved for use.

END OF SECTION

SECTION 16921

TEMPERATURE TRANSMITTER

PART 1 - GENERAL

1.1 THE REQUIREMENT

A. The Contractor shall furnish, test, install, and place into satisfactory operation the pressure transmitters, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Process Control and Information Systems

B. Instruments, General

PART 2 - PRODUCTS

2.1 TEMPERATURE TRANSMITTERS

A. Room Temperature Transmitters

1. Pressure transmitter shall be 28 VDC powered from PLC panel power supply, Foxboro I/A Series, or equal. Power supply shall be VDC powered from PLC panel power supply. Transmitter shall be wall mounted with bare transducer element below sensing room temperature. Signal output shall be 4 to 20 mA.

2. Temperature transducer shall be RTD type. Element shall be bare connected directly to transmitter. Adjustable dampening shall be provided. External zero adjustment shall be provided. Accuracy shall be +/- 0.0 degrees Fahrenheit.

PART 3 - EXECUTION

3.1 REQUIREMENTS

END OF SECTION

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SECTION 16923
SCADA NETWORK SYSTEMS

PART 1 - GENERAL

1.1 SCOPE

A. Sections Includes
   1. Description of required Data and Programming.

B. Furnish a complete operating data network as indicated on the Drawings, as shown on the cable or system block diagrams; and as specified herein.

C. SCADA will link with the existing SCADA network Via existing communications.

D. All connected equipment having Modbus / Ethernet connectivity will have all data points available to SCADA.

E. SCADA system existing at the central location will be modified to include all new and updated data points.

F. Related Sections: The Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the Contractor and its Sub-Contractors to review all sections to ensure a complete and coordinated project.

1.2 REFERENCES

A. TIA/EIA Standards:
   1. TIA/EIA-568-B (Series), Commercial Building Telecommunications Standards.
   2. TIA/EIA-569 (Series), "Commercial Building Standard for Telecommunications Pathways and Spaces"
   3. IEEE Series 802 standards.

1.3 DEFINITIONS

1.4 SUBMITTALS

A. Furnish complete submittals in accordance.

B. Furnish complete Product Data, Shop Drawings, Test Reports, Operating Manuals, Record Drawings, Manufacturer's certifications, Manufacturer's Field Reports, and other submittals as specified in Section 17200 and below.

C. Additional Requirements
   1. Test Reports
      a. As noted herein.
      b. Signed test results as described in Part 3 of this Section.
      c. Test results shall include:
         1) Narrative describing the test procedures followed.
         2) Block diagram of test set up.
         3) Manufacturer's information on test equipment used.
         4) Detailed test results.
         5) A narrative summarizing the results of the testing and identifying any further action required.

1.5 DELIVERY, STORAGE AND HANDLING

A. Store all equipment in a dedicated structure with space conditioning to meet the recommended storage requirements provided by the manufacturer:

1. Replace any components that are not stored in strict conformance with the manufacturer's recommendation.

1.6 PROJECT OR SITE CONDITIONS

A. Equipment shall be suitable for the installed site conditions including, but not limited to, material compatibility, site altitude, ambient temperature, and humidity conditions.

1.7 WARRANTY

PART 2 - PRODUCTS

2.1 NOT USED

PART 3 - EXECUTION

3.1 PREPERATION

A. Work with current system managers and staff to design SCADA screens.

B. Outline with system managers how data will be presented and used.

C. Do not proceed with programming until agreement is reached.

3.2 PROGRAMMING

A. All data points (tags) available to the PLCs and connected controllers and devices must be available to the SCADA system.

B. All process data must be recorded, stored and displayed in a usable manner.

C. New SCADA programming must not interfere with existing SCADA functions.

3.3 INSTALLATION

A. Installation of program code and updates must be scheduled with system managers to avoid interrupting current operations.

3.4 FIELD QUALITY CONTROL

A. Each data point must be tested and verified for accuracy.

B. Each trend and data log must be fully tested for proper operation.

C. All screens must be approved by system manager.

3.5 ADJUSTING

A. Perform all configuration and other set up, as required, to place the SCADA system into proper operation.

3.6 TRAINING

1. All operations staff and managers must be fully trained in:
    a. SCADA operation.
    b. Alarm notification response.
    c. Error conditions.
    d. Error recovery.
    e. Data usage.
    f. Data recovery.

g. Report printing.
h. Any other functions.

END OF SECTION

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SECTION 16930
HVAC SYSTEMS CONTROL

PART 1 - GENERAL

1.1 SCOPE

Furnish all labor, materials, equipment, appliances and perform all operations in connection with, and complete in strict accordance with, this section of specifications and the applicable drawings and subject to the terms and conditions of the contract for the following work:

A. Electrical work associated with the systems including, but not necessarily limited to:

1. All electrical installation including power distribution and special systems, is included in the scope of the general contract. Of specific concern are the control systems related to mechanical equipment. Responsibility for the control work is divided between the project electrician (Division 16) and his controls sub-contractor. The plant PLC system shall control HVAC systems.
2. All electrical work shall be in accordance with Division 16.
3. Division 16 shall provide all power to and throughout the building, to include motor control centers, breaker panels, and all other systems designated to Division 16, and specified herein. Division 16 shall install all conduit systems.
4. Division 16 shall run and connect all wiring and devices which power or control motors and other mechanical or control devices. Where control devices are located in power circuit, the controls contractor shall interrupt the circuit in the mechanical equipment junction box, wire through the control device and back to the junction box.
5. Breakers and disconnects, auxiliary contacts, standard pilot lights and magnetic starters are the responsibility of Division 16 and shall be as specified herein.
6. Auxiliary relays, low voltage transformers, control panel switches and devices, thermostats, pressure switches, electric operated valves, etc., are the responsibility of Division 16.
7. All wiring shall terminate at labeled terminal strips.

1.2 APPLICABLE SECTIONS

The General Conditions, Supplementary General Conditions, alternates and Addenda, applicable drawings and the technical specification including but not limited to the following;

A. Section “Electrical General Requirements”.

B. Section “Conductors and Cables”.

1.3 SUBMITTALS

A. The controls contractor shall provide shop drawings for control system circuits.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Terminal Blocks: DIN rail mounted, modular type, single layer, non-fused. Entreloc or approved equal.

B. Twisted, Shielded Pair Conductors for Control Wiring: Conductors shall be copper with 100 % shielding, plenum rated. Beldon type 89418 or approved equal. Cables shall be run in conduit.

C. Conductors: All control conductors shall be #14 AWG THWN minimum.

D. Labeling: All control conductors shall be labeled with a number corresponding to the mechanical control system drawings. All labeling shall be heat-shrink ink printed type by Panduit Pan-Quick LS3 system or equal.

PART 3 - EXECUTION

3.1 GROUNDING

A. Labeling: All control conductors shall be numerically labeled corresponding to the mechanical control systems record drawings.

B. Grounding Lugs: Ground all shielded pair shields at one end only to avoid ground loops. At terminal block connections, the shield shall be continuous from one conductor to another and shall be isolated from the local ground plane.

C. Conductors: All conductors shall be run in conduit unless specifically noted otherwise. The minimum size of conduit shall be 3/4" unless specifically noted otherwise.

END OF SECTION

SECTION 16933
CONTROL SYSTEMS - HUMAN MACHINE INTERFACE SOFTWARE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. General requirements for application software to be used in conjunction with the specified human machine interface hardware.

B. Related Sections

1. Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the CONTRACTOR and its Sub-Contractors to review all Sections to ensure a complete and coordinated project.

1.2 SUBMITTALS

C. Furnish complete submittals in accordance.

D. Furnish complete Product Data, Graphic Screens, Operating Manuals, Manufacturer's certifications, and other submittals as specified.

E. Additional Requirements:

1. Product Data:

a. Operating system requirements.

2. Graphic Screens:

a. Color printouts of each graphic screen and control pop-up.

1.3 QUALITY ASSURANCE

F. System Compatibility.

1. The software must be the standard operating software system designed specifically for use with the human machine interface hardware.

a. The software must be furnished and developed by the manufacturer of the human machine interface hardware.

1.4 WARRANTY

G. Provide extended 2 year manufacturer's warranty support as follows:

1. Dedicated technical support department or handled by programming staff or distributor.

2. Telephone hours for support shall be 24 hours, 7 days per week.

3. Email & Web support addresses.

4. Document download via website.

1.5 MAINTENANCE

H. Provide system upgrades and maintenance fixes for a period of two years from substantial completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The human machine interface graphic software system shall be manufactured by or if necessary or approved, compatible with the human machine interface hardware manufacturer.

B. Compatible with Modicon M340 PLC, approved by OWNER.

2.2 MANUFACTURED UNITS

C. Human machine interface software.

1. Provide a complete software package to be used for programming the necessary screens and operator interaction with the human machine interfaces.
2. Operating System:
    a. Microsoft Windows.
3. Software shall use preconfigured symbols, objects, graphics, and imported bitmaps for the generation of the displays.
4. Software shall allow bitmaps to be imported or exported to or from other applications.
5. Capable of generating custom reports, complete with screen prints.
6. Capable of working with multiple screens concurrently.
7. Shall provide dialog boxes for defining object attributes.
8. Objects shall be configured using fill in dialog boxes.
9. Graphic and text editor to allow custom formatting to customize and change the appearance of objects and text.
    a. Allow selection of different fill patterns to define object status.
10. As a minimum, provide the following object capabilities.
    a. Operator Inputs
        1) Momentary Push Button.
        2) Maintained Push Button.
        3) Latched Push Button.
        4) Multistate Push Button.
        5) Keypad Enable Button.
        6) Cursor Point.
    b. Control List Selectors.
        1) Standard Control List.
        2) Piloted Control List.
    c. Global Objects.
    d. Display Objects.
        1) Bar Graph.

2) Scale.

3) Message Display.

4) Multistate Indicator.

5) List Indicator.

6) Numeric Data Display.

e. Screen Selector Objects.

1) Go To.

2) Return.

3) Screen List Selector.

f. Embedded Variables.

1) Time.

2) Date.

3) Numeric Variable.

g. Graphics.

1) Lines.

2) Shapes.

3) Freeform Drawings.

4) Imported Graphics.

5) Background Text.

6) Selection Table for standard ISA symbols.

7) PID Controller Faceplate.

h. Alarm screens.

11. Documentation

a. The system shall provide complete user documentation, including examples of how to operate the various modules within the system.

b. The documentation must be in electronic format, HTML based with the ability to search for topics by keyword or search or specific text.

12. On-line Help

a. An on-line "help" facility, based upon Windows standard Hypertext, shall provide useful, context-sensitive information on the operation of the package.

1) This help facility shall be capable of being invoked on-line through a point-and-click operation.

2) The "help" facility must also support the ability to perform full text word search, add custom comments, bookmark topics, copy and pasting into another application, printing, and use of system fonts and colors.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All tags used and/or assigned as part of the application programming work shall use the Tag and Loop identifications found on the P&IDs.

B. Station Graphics:

1. For each device both in the treatment plant, and/or process area, a station graphic display shall be configured, this graphic shall include:

   a) Symbols for

      1) Pumps.

      2) Valves

      3) Major instruments.

      4) Flowmeters.

      5) Pressure transmitter.

      6) Level Transmitter

      7) Etc.

   b) Alarm symbols including intrusion alarm.

   c) Relevant test and operational data.

   d) Each pump and valve shall include indication of status:

      1) Hand.

      2) Off.

      3) Automatic

      4) Local.

      5) Remote.

      6) Run.

      7) Call.

      8) Fail.

      9) Open.

      10) Close.

      11) Hold.

      12) Modulate.

2. Change of state of pumps and valves shall be depicted by change in color.

3. Production and Usage Bar Graph:

   a) A display shall depict the production for each site and/or piece of equipment, as determined during the requisite graphics meeting, within the treatment plant, summarized to type, and total usage, with a bar graph and numeric value for each analog value.

3.2 TRAINING

C. The training shall be performed by pre-approved and qualified representatives of the manufacturer of the human machine interface hardware or a representative of the vendor supplying the control panel. A representative of the vendor supplying the control panel may perform the training only if the representative has completed the manufacturer's training course for the human machine interface software.

END OF SECTION

SECTION 16944

SOLAR ENERGY ELECTRICAL POWER GENERATION SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, connection, testing, and commissioning of solar energy electrical power generation systems.

B. The requirements of this Section apply to all sections of Division 16 related to solar energy electrical power generation systems.

1.3 DEFINITIONS

A. Unless otherwise specified or indicated, solar energy conversion and solar photovoltaic energy system terminology used in these specifications, and on the drawings, shall be as defined in ASTM E772.

1.4 QUALITY ASSURANCE

A. Solar Energy Electrical Power Generation System installer(s) shall demonstrate that they have successfully installed at least four projects within the past five years that, in aggregate, equal or exceed the size of the proposed project. The installer(s) shall provide written references for each of the referenced qualified projects to Resident Engineer.

B. Supports and racking for solar photovoltaic system installations shall be prepared by a licensed Structural Engineer whose structural engineering license is current and valid. For roof top installations on existing structure, the engineer shall provide review and structural analysis of the existing structure to ensure that the existing structure shall safely support the proposed installations. The engineer shall submit to Resident Engineer design documents such as engineering calculations, drawings (if applicable), the environmental loading analyses (including wind, snow, hail, and where applicable, seismic), and the rack and substrate’s ability to withstand these environmental forces.

C. If paralleling arrangement is desired, the system shall have anti-islanding capability such that it is incapable of exporting power to the utility distribution system in the absence of utility power. Paralleling must be approved by serving electric utility. Provide written correspondence from the utility confirming its requirements.

D. Investigate whether the Resident Engineer or local VAMC’s environmental entities require environmental impact studies which may include, but are not limited to, effects upon wildlife. The Contractor shall determine which entity has jurisdiction over environmental matters and shall make appropriate inquiry and comply with all applicable regulations.

E. Investigate any other local ordinances that may apply to installation of a solar energy electrical generating system in the proposed location. Bring any conflicts with the drawings and specifications to the attention of the Resident Engineer.

G. Warranties: The solar energy electrical generating system shall be subject to the terms of FAR Clause 52.246-21, except that the warranty period shall be as noted for the items below:

1. Solar photovoltaic modules and inverter: 10 year manufacturer's warranty against defects in materials and workmanship.

2. Power output: 25 year manufacturer's power output warranty, with the first 10 years at 90% minimum rated power output and the balance of the 25 years at 80% minimum rated power output.

1.5 SUBMITTALS

A. Where proposed system shall be a Net Meter project, prepare appropriate applications and submittals to the Resident Engineer. Where proposed system shall be connected before the serving electric utility's meter and tied directly to the grid, prepare appropriate applications and submittals to the Resident Engineer. In all cases, the serving electric utility may have a requirement for further electrical studies, which may include or not be limited to power factor analysis, short circuit protection studies, grid wiring adequacy, or capacities of upstream equipment. If such requirements exist and are required by the serving electric utility, these requirements shall be fulfilled by the Contractor. Provide written documentation confirming the utility's approval of the interconnection of the solar energy electrical power generation system with the utility system to the Resident Engineer.

B. Submittals shall comply with the following requirements:

1. Shop Drawings:

   a. Submit sufficient information to demonstrate compliance with drawings and specifications.

   b. Include electrical ratings, dimensions, mounting details, materials, required clearances, terminations, weight, wiring and connection diagrams, accessories, and nameplate data.

   c. Include shop drawings for foundations and other support structures.

2. Product Data:

   a. Include detailed information for components of the solar energy electrical generation system.

      1. Wiring.

      2. Inverter.

      3. Photovoltaic modules.

      4. Rack and support assemblies.

      5. Instrumentation.

6. Switchgear.

7. DC and AC disconnects.

8. Combiner boxes.

9. Monitoring systems.

b. Certification from the manufacturer that the system has been seismically tested to International Building Code requirements. Certification shall be based upon simulated seismic forces on a shake table or by analytical methods, but not by experience data or other methods.

3. Manuals:

a. Submit, simultaneously with the shop drawings, complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering replacement parts.

1. Safety precautions.
2. Operator restart.
3. Startup, shutdown, and post-shutdown procedures.
4. Normal operations.
5. Emergency operations.
6. Environmental conditions.
7. Preventive maintenance plan and schedule.
8. Troubleshooting guides and diagnostic techniques.
9. Wiring and control diagrams.
10. Maintenance and repair procedures.
11. Removal and replacement instructions.
12. Tracking systems (where applicable).
13. Spare parts and supply list.
14. Parts identification.
15. Testing equipment and special tool information.
16. Warranty information.
17. Testing and performance data.
18. Contractor information.

b. If changes have been made to the maintenance and operating manuals originally submitted, then submit updated maintenance and operating manuals two weeks prior to the final inspection.

4. Certifications: Two weeks prior to final inspection, submit the following.
   a. Certification by the manufacturers of all major items of the solar energy electric generation system that the system conforms to the requirements of the drawings and specifications, and that they have jointly coordinated and properly integrated their equipment and controls to provide a complete and functional installation.
   b. Certification by the Contractor that the solar energy electric generation system has been properly installed, adjusted, tested, commissioned, and warrantied. Contractor shall make all necessary field measurements and investigations to ensure that the equipment and assemblies meet contract requirements.
5. Estimated Annual Power Output: Submit calculated annual power output for each of the proposed solar photovoltaic systems. Provide independent calculations for each fixed system.

C. If equipment submitted differs in arrangement from that shown on the drawings, provide drawings that show the rearrangement of all associated systems. Approval will be given only if all features of the equipment and associated systems, including accessibility, are equivalent to that required by the contract and acceptable to the Resident Engineer.

D. Submittals and shop drawings for independent but related items shall be furnished together and complete in a group. Coordinate and properly integrate materials and equipment in each group. Final review and approval will be made only by groups.

1.6 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.

B. American Society for Testing and Materials (ASTM):
E772-15 (R2021)............Standard Terminology of Solar Energy Conversion
E1038-10 (R2019)..........Standard Test Method for Determining Resistance of Photovoltaic Modules to Hail by Impact with Propelled Ice Balls

C. Institute of Electrical and Electronics Engineers (IEEE):
519-22 ....Recommended Practices and Requirements for Harmonic Control in Electric Power Systems
937-19 ....Recommended Practice for Installation and Maintenance of Lead-Acid Batteries for Photovoltaic (PV) Systems
1013-19 ....Recommended Practice for Sizing Lead-Acid Batteries for Stand-Alone Photovoltaic (PV) Systems

1361-14 ....Guide for Selection, Charging, Test and Evaluation of Lead-Acid Batteries Used in Stand-Alone Photovoltaic (PV) Systems

1526-20 ....Recommended Practice for Testing the Performance of Stand-Alone Photovoltaic Systems

1547-18 ....Standard for Interconnecting Distributed Resources with Electric Power Systems

1561-19 ....Guide for Optimizing the Performance and Life of Lead-Acid Batteries in Remote Hybrid Systems

1562-21 ....Guide for Array and Battery Sizing in Stand-Alone Photovoltaic (PV) Systems

1661-19 ....Guide for Test and Evaluation of Lead-Acid Batteries Used in Photovoltaic (PV) Hybrid Power Systems

D. International Code Council (ICC):

IBC-21..International Building Code

E. National Electrical Manufacturer's Association (NEMA):

250-20 ....Enclosures for Electrical Equipment (1,000 Volts Maximum)

F. National Fire Protection Association (NFPA):

70-23 ....National Electrical Code (NEC)

70E-21 ....Electrical Safety in the Workplace

G. Underwriters Laboratories (UL):

6-22 ....Electrical Rigid Metal Conduit – Steel

94-23 ....Tests for Flammability of Plastic Materials for Parts in Devices and Appliances; Ed 6

797-07 ....Electrical Metallic Tubing – Steel

969-17 ....Standard for Marking and Labeling Systems

1242-06 ....Standard for Electrical Intermediate Metal Conduit – Steel

1703-02 ....Standard for Flat-Plate Photovoltaic Modules and Panels

1741-21 ....Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources

PART 2 - PRODUCTS

2.1 GENERAL

A. Provide materials to fabricate functioning photovoltaic system in accordance with ASTM, IEEE, NEMA, NFPA, and UL, as specified in this section, and as shown on the drawings.

B. Factory-prefabricated solar equipment packages which include photovoltaic modules, batteries or other energy storage, inverters, and controls and which meet the requirements of this section are acceptable.

2.2 GROUNDING

A. All applicable components of the solar energy electrical power generating system must be grounded per latest NEC requirements.

B. DC Ground-Fault Protector:
   1. Shall be listed per UL 1703.
   2. Shall comply with requirements of the NEC.

2.3 PHOTOVOLTAIC ARRAY CIRCUIT COMBINER BOX

A. Shall be listed to UL 1741.

B. Shall include internal overcurrent protection devices with dead front.

C. Shall be contained in non-conductive NEMA Type 4X enclosure.

D. Up to 48 volts DC: Shall use UL-listed DC breakers that meet NEC requirements for overcurrent protection.

E. Up to 600 volts DC, paralleling system: Shall use fuses instead of breakers.

F. Ground and pole-mounted arrays shall have a separate combiner box mounted to the pole itself.

G. Where applicable, combiner box shall be a disconnecting combiner box.

2.4 SWITCH/DISCONNECTING MEANS

A. Shall be UL-listed, in accordance with the NEC, as shown on the drawings, and as specified.

B. Utility External Disconnect Switch (UEDS): Refer to Resident Engineer, as several states do not require UEDS for small solar photovoltaic systems if the inverter provides the same function per NEC. Coordinate requirements with serving electric utility.

2.5 WIRING SPECIALTIES

A. Direct Current Conductors:
   1. If Exposed: Shall be USE-2, UF (inadequate at 60°C [140°F]), or SE, 90°C [194°F] wet-location rated and sunlight-resistant (usually for tracking modules).
   2. If in Conduit: Shall be RHW-2, THWN-2, or XHHW-2 90°C [194°F], wet-location rated.

B. Conduits and Raceways:
   1. Shall use steel conduit listed per UL 6, UL 1242, UL 797 (as appropriate), except for tracking modules. Weathertight EMT installations shall be allowed for DC wiring in weather-protected areas.
   2. Shall use expansion joints on long conduit runs.
   3. Shall not be installed on photovoltaic modules.

C. Enclosures subject to weather shall be rated NEMA 3R or better.

D. Cable Assemblies and Junction Boxes:
   1. Shall be UL-listed.
   2. Shall be rated to 5VA flammability per UL 94.

E. Prohibited Wiring Materials: Those which are not UL-listed, or listed materials used in environments outside those covered in their listing.

2.6 DC-AC INVERTER

A. Shall be listed to UL 1741.

B. Shall comply with IEEE 519 and IEEE 1547.

C. Shall be listed per FCC Part 15 Class A.1.

D. Shall have stand-alone, utility-interactive, or combined capabilities.

E. Shall include maximum power point tracking (MPPT) features.

F. Shall include anti-islanding protection if paralleling arrangement is required.

2.7 SOLAR PHOTOVOLTAIC (PV) MODULES

A. Minimum Performance Parameters as per UL 1703.

B. Photovoltaic Panel Types:
   1. Monocrystalline: Listed to UL 1703.
   2. Polycrystalline: Listed to UL 1703.
   3. Thin-Film/Flexible: Listed to UL 1703.
   4. Building-Integrated & Solar Shingles: Listed to UL 1703.

C. Module and System Identification

1. Module or Panel:

    a. Listed to UL 969 for weather resistance.
    b. Listed to UL 1703 for marking contents and format.

2. Main Service Disconnect: per NEC.
3. Identification Content and Format: per NEC.
4. Identification for Inverter: per NEC.

D. Bypass diodes shall be built into each PV module either between each cell or each string of cells.

E. Other Components: per UL 1703.

F. Hail Protection: Compliant with testing procedure per ASTM E-1038.

G. Lightning Protection: Shall ground according to manufacturer instructions per UL 1703.

H. Access, Pathways, and Smoke Ventilation: Per IFC 605.3, access and spacing requirements must be observed in order to: ensure access to the roof, provide pathways to specific areas of the roof, provide for smoke ventilation opportunities area, and, where applicable, provide emergency access egress from the roof.

I. Fire Classification:
    1. IBC 1505.8 for building-integrated photovoltaic and solar shingles.
    2. IBC 1509.7.2: Although not technically enforceable, every effort shall be made to ensure the solar photovoltaic module is not combustible.

2.10 COLLECTOR SUPPORTS

A. Wind Resistance Requirement:
    1. For rack-mounted: per IBC 1509.7.1.
    2. For building-integrated photovoltaic and solar shingles: IBC 1507.17.3.

B. Mechanical Load Requirement: per UL 1703.

2.11 INSTRUMENTATION

A. Meters: If applicable and system is grid-connected, use net smart meter provided by the serving electric utility.

B. Sensors:
    1. Temperature sensor shall be a component in the MPPT control system.
    2. May install additional data acquisition sensors to measure irradiance, wind speed, and ambient and PV module temperatures. Any additional sensors shall require a conduit separate from the current conductor conduit.

C. Data logger/Monitoring System: Shall be a packaged system capable of string-level monitoring or in the case of micro-inverters, capable of monitoring and logging an individual module’s information.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install the solar photovoltaic system in accordance with the NEC, this section, and the instructions of the manufacturer.

B. Prior to system start-up, ensure no copper wire remains exposed with the exception of ground wire as allowed in certain circumstances per manufacturer's instructions.

C. Systems shall be adequately anchored and braced per details on structural contract documents to withstand seismic forces at the locations where installed.

D. Wiring Installation: Workers shall be made aware that photovoltaic modules are energized electrically when there is any ambient light source; therefore, workers shall take appropriate safety precautions to prevent accidents. Utilize on-site measurements in conjunction with the design drawings to accurately cut wires and layout before making permanent connections. Locate wires out of the way of windows, doors, openings, and other hazards. Ensure wires are free of snags and sharp edges that have the potential to compromise the wire insulation. All cabling shall be mechanically fastened. If the system is roof-mounted, it shall have direct current ground fault protection according to NEC. Ensure breakers in combiner box are in the off position (or fuses removed) during combiner box wiring.

E. Instrumentation: Install instruments as recommended by the manufacturer. Locate control panels inside a room accessible only to qualified persons.

F. Building-Integrated Photovoltaic Installations: Building-integrated photovoltaic modules/shingles shall be installed in accordance with the manufacturer's installation instructions.

G. Rack-Mounted Photovoltaic Installations: Rack-mounted photovoltaic modules shall be installed in accordance with the manufacturer's installation instructions.

H. Ground and Pole-Mounted Photovoltaic Installations: If structure is used as equipment grounding conductor, ensure compliance with NEC. Wiring shall not be readily accessible.

I. Tracking System Installations: Disconnect shall be within sight of the tracking motor.

J. Provide safety signage.

K. Coordinate installation with roofing contractor. Remove, replace, patch, and repair existing roofing materials and surfaces cut or damaged during installation of the solar energy electrical power generation system, by methods and with materials so as not to void existing roofing system warranty. Notify roof warrantor before proceeding with the work.

3.2 FIELD QUALITY CONTROL

A. Field Inspection: Perform in accordance with manufacturer's recommendations. Prior to initial operation, inspect the solar energy electrical power generation system for conformance to drawings, specifications, and NEC. In addition, include the following:

1. Visual Inspection and Tests:

   a. Compare equipment nameplate data with specifications and approved shop drawings.
   b. Inspect physical, electrical, and mechanical condition.
   c. Verify required area clearances.
   d. Verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey after energization.
   e. Verify the correct operation of all sensing devices, alarms, and indicating devices.
   f. Verify that all cable entries from top of junction boxes are sealed per junction box rating.
   g. Verify all connections and integrity of printed circuit boards in all applicable junction boxes.

B. Tests: Provide equipment and apparatus required for performing tests. Correct defects disclosed by the tests and repeat tests. Conduct tests in the presence of the Resident Engineer.

1. Module String Voltage Test: Prior to connecting wiring to the combiner box, use a digital multi-meter to ensure each series string's polarity is correct.
2. Operational Tests: Perform tests in accordance with the manufacturer's written recommendations. Tests for stand-alone systems shall be performed per IEEE 1526.

3.3 FOLLOW-UP VERIFICATION

A. Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that the solar photovoltaic electrical power generation system is in good operating condition and properly performing the intended function.

3.4 COMMISSIONING

A. Comply with the requirements of Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

B. Only qualified personnel shall connect the solar photovoltaic electrical power generation system to the serving electric utility grid.

C. If the system is grid-tied, the Contractor shall coordinate with the serving electric utility to establish an interconnection agreement.

D. Connect the solar photovoltaic electrical power generation system to the serving electric utility grid only after receiving prior approval from the utility company.

3.5 INSTRUCTION

A. A complete set of operating instructions for the solar photovoltaic electrical power generation system shall be laminated or mounted under acrylic glass and installed in a frame near the equipment.

B. Furnish the services of a factory-trained technician for one, 4-hour training period for instructing personnel in the maintenance and operation of the solar photovoltaic electrical power generation system, on the date requested by the Resident Engineer.

END OF SECTION