SECTION 26 05 00
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 26.

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 26.

E. The licensed journeyman assigned to supervise the performance of Division 26 electrical work, shall be required to be on the job site at all times, while Division 26 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 26 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 26.

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 01 70 00 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 USE OF SUBSTITUTES

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 SITE CONDITIONS

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 26 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 26 05 08 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 01 70 00 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 26 05 05
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-26 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.

B. Refer to Section 01 34 00 for additional requirements.

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.

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SECTION 26 05 07
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 shall not 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.

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SECTION 26 05 08
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 01 50 00, 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 40 10 00, Process Control and Instrumentation Systems, shall be completed before commencement of the 7-day test specified in Section 26 05 08, 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 26 05 00, 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 26 05 00, 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 01 30 00, 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 01 30 00, 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 26 05 00, 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 01 30 00, 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 26 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 26 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 01 65 00 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 -

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SECTION 26 05 09
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 26 05 00 - 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 26 05 10
EQUIPMENT FOR HAZARDOUS LOCATIONS

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. Provide raceways, fittings, seal-offs, conductors, and related products for a complete and operational system for hazardous locations.
2. For power, alarm, and control systems for equipment specified elsewhere, provide raceways, fittings, seal-offs, conductors, and related products for a complete and operational system for hazardous locations

1.2 APPLICABLE SECTIONS

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

1. Section 26 05 00 - Electrical General Requirements.

1.3 QUALITY ASSURANCE

A. Comply with provisions of sections 26 05 00, Electrical General Requirements, and 26 05 19, Conductors and Cables. Conform to applicable codes and regulations regarding toxicity of combustion products of insulating materials.

PART 2 PRODUCTS

2.1 METAL CONDUIT AND TUBING

A. Rigid Steel Conduit: ANSI C80.1.

B. PVC Coated Rigid Steel Conduit: ANSI C80.1/NEMA RNI-1989.

C. Liquid-tight Flexible Metal Conduit and Fittings: UL 360. Fittings shall be listed for use with raceway (Class I, Division 2 locations only).

2.2 CONDUIT BODIES

A. General: Types, shapes, and sizes as required to suit individual applications and NEC requirements. Conduit, fittings, equipment, and methods shall comply with NFPA70 with area classifications as shown on drawings per NFPA80. J-boxes: Killark GRSS/GRSSA series, Seal-offs: Killark ENY/EY/EYS series, Cord Connectors: Killark ZE series.

B. Metallic Conduit and Tubing: Use metallic conduit bodies. Use bodies with threaded hubs for threaded raceways.

2.3 CONDUCTORS

A. General: Provide wire and cable suitable for the temperature, conditions and location where installed.

B. Conductors: Provide stranded conductors for all power, lighting, and central circuits.

C. Conductor Material: Copper for all wires and cables.

D. Insulation: Provide XHHW-2 insulation for all conductors.

E. Color Coding for phase identification in accordance with Section 26 05 19 of these specifications.

2.4 CONNECTORS FOR CONDUCTORS:

A. Provide UL-listed factory-fabricated, solderless metal connectors of sizes, ampacity ratings, materials, types and classes for applications and for services indicated. Use connectors with temperature ratings equal to or greater than those of the wires upon which used.

2.5 FABRICATED MATERIALS

A. Outlet Boxes: Provide cast steel outlet wiring boxes, of shapes, cubic inch capacities, and sizes, including box depths as indicated, suitable for installation at respective locations. Construct outlet boxes with mounting brackets, and with cable and conduit-size threaded hubs in bottom and sides.

1. Outlet Box Accessories: Provide outlet box accessories as required for each installation, including box supports, and brackets, which are compatible with outlet boxes being used to fulfill installation requirements for individual wiring situations. Choice of accessories is Installer's code-compliance option.

2.6 NON-FUSIBLE SWITCHES

A. For equipment 2 horsepower and smaller, shall be horsepower rated; toggle switch type; quantity of poles and voltage rating as indicated. For equipment larger than 2 horsepower, switches shall be fusible type.

2.7 JUNCTION BOXES

A. Junction boxes with screwed-on gasketed hazardous location rated covers shall be sized as shown and detailed on the drawings.

B. Junction or pull boxes which are required but not shown shall be sized according to requirement of Articles 370 and 373 of NEC.

2.8 OUTLET BOXES

A. Boxes shall be provided in the wiring or raceway systems where ever required for pulling of wires, making connections, and mounting of devices or fixtures.

B. Boxes in exposed conduit runs shall be cast metal condulets with threaded hubs installed exposed. Non-metallic boxes are not approved.

C. Each box shall be metal and shall have the volume required by the National Electrical Code for the number of conductors enclosed in the box. Boxes for mounting lighting fixtures shall be not less than 4 inches octagonal or 4 inches square except that smaller boxes may be installed as required by fixture configuration, as approved. Boxes for use with raceway systems shall not be less than 1-1/2 inches deep except where shallower boxes required by structural conditions are approved. Boxes for other than lighting-fixture outlets shall be not less than 4 inches square.

2.9 MOTOR STARTERS AND CONTROLS NOT IN MOTOR CONTROL CENTER

A. Combination factory assembled fused disconnect and magnetic starter shall be as indicated. NEMA size as noted. Each shall be equipped with two N.O. and two N.C. auxiliary contacts and control transformer to provide 120 volt for starter controls. Enclosures shall be suitable for hazardous locations as indicated on the drawings.

B. Remote push button control shall be "HAND-OFF-AUTO" mounted in cast-metal condulet box with threaded hubs and fitted with cover suitable for use in hazardous locations as indicated.

C. Solid state motor overloads and Pilot devices as detailed.

D. Manufacturers: Shall be as manufactured by one of the following:

1. Cutler Hammer
2. Square "D"
3. Allen Bradley
4. General Electric

PART 3 EXECUTION

3.1 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment specifications in Division 8 through 44 for rough-in requirements.

3.2 ELECTRICAL INSTALLATIONS

A. General: Sequence, coordinate, and integrate the various elements of electrical systems, materials and equipment. Comply with the following requirements.

B. Install systems, materials and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.

C. 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.

D. Install systems, materials and equipment giving right-of-way priority to systems required to be installed at a specified slope.

3.3 INSTALLATION OF WIRES AND CABLES

A. General: Install electrical cables, wires, and connectors in compliance with NEC.

B. Pull conductors simultaneously where more than one is being installed in the same raceway. Use UL listed pulling compound or lubricant, where necessary.

C. Use pulling means including fish, tape, cable, rope, and basket weave wire/cable grips which will not damage cables or raceways. Do not use rope hitches for pulling attachment to wire or cable.

D. Provide adequate length of conductors within electrical enclosures and train the conductors to terminal points with no excess. Bundle multiple conductors, with conductors larger than No. 10 AWG cabled in individual circuits. Make terminations so there is no bare conductor at the terminal.

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

3.4 FIELD QUALITY CONTROL

A. Prior to energizing, check installed wires and cables with megohm meter to determine insulation resistance levels to assure requirements are fulfilled.

B. Prior to energizing, test wires and cables for electrical continuity and for short-circuits.

C. Subsequent to wire and cable hook-ups, energize circuits and demonstrate proper functioning. Correct malfunctioning units, and retest to demonstrate compliance.

3.5 INSTALLATION OF ELECTRICAL BOXES AND FITTINGS

A. General: Install electrical boxes and fittings as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC and NECA's "Standard of Installation", and in accordance with recognized industry practices to fulfill project requirements.

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

C. Provide weather-tight outlets for interior and exterior locations exposed to weather or moisture.

D. Provide threaded plugs to cap unused hubs.

E. Install electrical boxes in those locations which ensure ready accessibility to enclosed electrical wiring.

F. Fasten electrical boxes firmly and rigidly to substrates, or structural surfaces to which attached, or solidly embed electrical boxes in concrete or masonry.

G. Provide electrical connections for installed boxes. Subsequent to installation of boxes, protect boxes from construction debris and damage.

H. Provide seal-offs as required per NEC Chapter 5. Use Nema 7 Fixtures in explosive environments or Class I Div 1 areas and on conduit and devices on the hazardous side of a seal-off. Use Class I Div 2 fixtures in Class I Div 2 areas and on conduit and devices on the hazardous side of a seal-off.

I. Where shown on drawings, make splices on the hazardous side of a seal-off to allow for easier replacement of equipment most likely to fail and allow wiring less-likely to fail to remain intact.

3.6 GROUNDING

A. Upon completion of installation work, properly ground electrical boxes and demonstrate compliance with requirements.

- END OF SECTION -

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SECTION 26 05 19
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 26 05 00: Electrical General Requirements.

B. Section 26 05 08: 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) 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. 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 26 05 22
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 jack 18 inches above finished floor.

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

G. Install telephone 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 26 05 24
EQUIPMENT WIRING

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:

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

C. 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.

D. 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.

E. 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.

F. 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.

G. 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.

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

1.2 APPLICABLE SECTIONS

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

B. Section 26 05 00 - Electrical General Requirements.

1.3 REFERENCES

A. Section 01 50 00 - 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 01 30 00 – Submittals: General.

B. Section 26 05 00 - 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.

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SECTION 26 05 26
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 26 05 00 - 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 01 30 00 – Submittals: General.

B. Section 26 05 00 - 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 26 05 05 - 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

A. Material: Stranded copper, tinned.

B. 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 -

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SECTION 26 05 30
CONDUITS

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 Areas (NEAM 3R): Areas outdoors exposed to the elements.
c. Corrosive Process Areas (NEMA 4X): Areas requiring corrosion resistant (NEMA 4X) construction all outdoor corrosive environments and 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. Some corrosive chemicals include acids, bases, salt, chlorines (gas and liquids), H2S and other corrosive gasses.
d. 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.
e. 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 3R[1] Outdoor	NEMA 4X[1] Indoor Corrosive	NEMA 12[1]	NEMA 7 Classified Explosion Proof/Process Area
Conduit (exposed)	GRS	GRS	PVC 8 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	Galvanized Steel	Stainless steel	Aluminum	Stainless steel
Fastening hardware and hanger	Cadmium plated steel	Cadmium plated steel	Stainless steel	Cadmium plated steel	Stainless steel
Control Stations[2,6]	Painted Steel	Painted Steel	Non-Metallic	Painted Steel	Classified

Enclosures[2,6]	Painted Steel	Painted Steel	Non-Metallic	Painted Steel	Classified
Receptacles[2] Surface Recessed	General General	WP[8] WP[8]	WP[8] N/A	WP[8] WP[8]	Classified N/A
Switches[2] Surface Recessed	General General	WP[8] WP[8]	WP[8] N/A	WP[8] 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.
9. 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: Outdoor where exposed, Interior where exposed where not exposed to moisture or corrosive atmosphere. Shall not be used in process areas of the plant.

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

1. Suitable for direct burial. 1” minimum size.
2. Fittings shall be threaded or chemically welded or heat welded type water-tight 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

F. 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.

G. 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.

H. FLEXIBLE METAL CONDUIT: UL 1.

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

I. RIDGED ALUMINUM CONDUIT:

1. 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.
2. 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.

J. 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.

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SECTION 26 05 32
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. No splices are allowed underground due to high water table at the site.

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 31 22 00 - Earthworks

B. Section 26 05 00 - Electrical General Requirements.

C. Section 26 05 19 – Conductors and Cables.

PART 2 PRODUCTS

2.1 DUCTS

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

B. Duct elbows, bends, and off-sets shall be per the manufacturer’s requirements. Metal or PVC conduits underground are not allowed.

C. Splices shall be water-tight in order to minimize the entrance of water.

PART 3 EXECUTION

3.1 CONDUIT BANKS

A. Each ductbank shall be completely encased in red concrete for medium voltage cable, or bedding sand otherwise. Thickness of encasement over, under and around ductbank shall be not less than 3 inches as detailed. All ductbanks shall include a grounding electrode conductor as detailed.

B. Unless noted otherwise, the top of the concrete envelope shall be not less than 2'-6" 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.

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 if at all 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. For this particular project, the conduit will lay in the same trench as the piping. Coordinate trench requirements with piping trench and with piping trench contractor.

- END OF SECTION -

SECTION 26 05 34
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 26 05 22, 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 26 05 74
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:
23. Certification that the motor meets the requirements of NEMA MG-1 1993 part 31.
24. 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

B. 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 7,300 feet above mean sea level. Motors shall meet the criteria as specified in NEMA MG 1 for usual environmental conditions.

C. Operating Conditions

D. 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:

1. The rotor shall be dynamically balanced according to NEMA Standards. Balance limits shall be ½ 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 affecting 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 oF 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 1/2 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.
2. Locked rotor current shall not be greater than specified with NEMA Standard MG 1-10.36, 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.
2. Motors shall be furnished with Class F insulation, rated to operate at a maximum ambient temperature of 40°C and at the altitutde where the motors will be installed and operated, without exceeding temperature rise limits stated in NEMA MG 1-12.42 for a Class B insultation 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 the 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 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) It is the OWNER/CONTRACTOR’S responsibility to perform the motor starting requirement coordination, and to notify the ENGINEERO 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.
2. Voltage: All three phase motors shall be suitable for operation on 208, 230 and 460 VAC, unless otherwise indicated on the electrical plans.
3. 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.
4. 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 40°C and at the altitudes where the motors will be installed and operated, without exceeding temperature rise limits stated in NEMA MG 1-12.42 for Class B insulation at a 40 °C ambient, and without using the service factor.
5. Motor Bearings:
   a. Antirfriction, re-greaseable, and filled initially with grease suitable for ambient temperature to 40°C.
      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.
2. 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.
3. All vertical motors shall have a Service Factor of 1.15.
4. Motor Bearings:
   a. Antifriction, oil lubricated, and filled initially with oil suitable for ambient temperatures to 40°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 40°C ambient.
2. Totally Enclosed Fan Cooled:
   a. Cast iron conduit box.
   b. 1.15 service factor at 40°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.
      5) 1.15 service factor at 40°C ambient.
      6) Tapped drain holes with Type 316 stainless steel plugs for frames 286T and smaller.
      7) Automatic breather and drain devices for frames 324T and larger.
      8) 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.
3. Boxes shall be furnished with the size and number of openings as required for the conduits indicated on the Drawings.
4. Boxes shall be rotatable through 360 degrees in 90 degree increments.
5. 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 lbs (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 contract 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 251 horsepower shall be thermal switches, NEMA MG 1-12.57, Type 2.
3. Over temperature alarms for motors rated 100HP and less than 250HP shall also include a minimum of six 100 OHM Platinum RTD’s embedded in the motor windings, and one 100 OHM for each bearing to the PLC for monitoring and alarming. Shutdown in auto capability shall be provided and coordinated with owner. Wiring to an external junction box shall be provided.

4. Over temperature protection for motors rated 250 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.

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SECTION 26 09 13
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.

1.4 NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

A. NEMA 250 (1985; Incl. Rev. I and 2; ICS-6) Enclosures for Electrical Equipment

B. NEMA ICS 1 (1988) General Standards for Industrial Controls and Systems

1.5 UNDERWRITERS LABORATORIES, INC. (UL)

A. UL 50 Enclosures for Electrical Equipment

B. UL 508 Industrial Control Equipment

1.6 SUBMITTALS

A. Provide complete submittal information for the control devices in accordance with Section 26 05 00.

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.

E. 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.

d. 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.
3. Two wires on one terminal block will not be allowed.
4. 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.
5. 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 -

SECTION 26 16 00
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 in accordance with Section 26 05 09.
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 26 – 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:

1. AC Power Distribution: Red
2. DC Power and Control: Blue
3. Instrument: Black and white twisted shielded pair.

4. 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 as described in Section 26 35 53.

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 (NOT USED)

- END OF SECTION -

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SECTION 26 20 00
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 26 05 00.

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 31 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 26 24 17 – 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

2.1 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 (UREF), 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 26 05 00 for other requirements for final acceptance.

- END OF SECTION -

SECTION 26 22 00
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. In accordance with Section 26 05 00.

B. 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 Section 26 05 26.

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 26 24 16
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

A. The panelboard(s) and circuit breaker(s) referenced herein are designed and manufactured according to the latest revision of the following specifications.

1. NEMA PB 1 – Panelboards
2. NEMA PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
3. NEMA AB 1 - Molded Case Circuit Breakers
4. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
5. UL 50 - Enclosures for Electrical Equipment
6. UL 67 – Panelboards
7. UL 98 - Enclosed and Dead-front Switches
8. UL 489 - Molded-Case Circuit Breakers and Circuit Breaker Enclosures
9. CSA Standard C22.2 No. 29-M1989 - Panelboards and Enclosed Panelboards
10. CSA Standard C22.2 No. 5-M91 - Molded Case Circuit Breakers
11. Federal Specification W-P-115C - Type I Class 1
12. Federal Specification W-C-375B/Gen - Circuit Breakers, Molded Case, Branch Circuit And Service.
13. NFPA 70 - National Electrical Code (NEC)
14. 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.

B. Refer to Sections 26 05 00 and 26 05 05 for additional requirements.

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 26 35 53 – Transient Voltage Surge Suppression

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Square D Company Type NF - Class 1670.

B. Cutler Hammer.

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. Shall be Square D type circuit breakers. 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. All 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 each branch circuit panelboard. See Section 26 35 53 for requirements.

PART 3 EXECUTION

3.1 INSTALLATION

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 -

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SECTION 26 24 21
MOTOR STARTERS

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:

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:

Section 26 05 00 - Electrical General Requirements
Section 26 28 13 – Fuses
Section 26 05 26 – Grounding and Bonding
Section 26 09 13 – 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.

1.4 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.

1.5 CLEANING AND LUBRICATION

A. All equipment shall be thoroughly cleaned by the CONTRACTOR before final acceptance. The CONTRACTOR shall provide lubrication for all equipment furnished by him.

1.6 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.

1.7 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
2.	ANSI C89.1 (NEMA ST1)	Specialty Transformers (except General Purpose Type)
3.	NEMA AB-1	Molded Case Circuit Breakers
4.	NEMA ICS1	General Standards for Industrial Control and Systems
5.	NEMA 1CS2	Industrial Control Devices, Controllers and Assemblies
6.	ANSI C1 (NFPA70)	National Electrical Code
7.	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.

B. 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 26 26 00
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 26 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 26 28 13
FUSES

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:

B. Fuses.

C. Spare Fuse Cabinet.

1.2 APPLICABLE SECTIONS

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 26 05 00 - Electrical General Requirements
2. Section 26 05 19 – Conductors and Cables

1.3 ACCEPTABLE MANUFACTURERS

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 FUSE TYPES AND RATINGS

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, low 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 INSTALLATION

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 26 28 19
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 26 05 00 - Electrical General Requirements
2. Section 26 05 09 - Electrical Identification
3. Section 26 28 13 – Fuses

1.2 SUBMITTALS

A. Submit product literature including manufacturer part number, model number, material, size, ratings, and specifications.

B. Refer to Section 26 05 00 for submittal requirements.

PART 2 PRODUCTS

2.1 MATERIALS

A. Manufacturer

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 26 29 23
PULSE WIDTH MODULATED VARIABLE FREQUENCY DRIVE

PART 1 GENERAL

1.1 SCOPE OF WORK

A. Provide all labor, materials, equipment and incidentals required and install, place in operation and field test pulse variable frequency drive.

B. The adjustable frequency controller shall be a flux vector sine-wave, pulse width modulated (PWM) design. A modulation method which incorporates “gear changing” is not acceptable. The final responsibility of the completed drive system is that of the manufacturer. Qualified system integration will be by manufacturers approved and should use methods and procedures approval in writing by the VFD manufacturer prior to shipping the drive system to customer site. One manufacturer shall provide all drives systems under this contract. The drive systems shall be manufactured within the United State of America to alleviate concerns of future spare part availability and technical support. All drive systems shall be purchased and furnished by the CONTRACTOR.

C. Drives for motors over 60HP shall be configured with active harmonics mitigation.

1.2 QUALITY ASSURANCE STANDARDS

A. The entire VFD system as described herein shall be assembled and factory tested to assure a properly coordinated system.

B. Codes: Provide equipment is full accordance with the latest applicable rules, regulations, and standards of:

1. Local Laws and Ordinances.
2. State and Federal Laws.
3. National Electrical Code (NEC).
4. Underwriters Laboratories (UL).
5. American National Standards Institute (ANSI).
6. National Electrical Manufactures Association (NEMA).
7. Institute of Electrical and Electronic Engineers (IEEE).

C. The complete drive system shall be UL listed.

D. The manufacturer will have a minimum of 12 years experience in Integrated Bi-polar Transistor technology.

1.3 ACCEPTABLE EQUIPMENT MANUFACTURERS FOR 18 PULSE DRIVES

A. ABB

1.4 SUBMITTALS

A. Submittals shall conform in all respect to this section.

B. Submittals shall be prepared specifically for this project by the VFD manufacturer. For this specific application submittal package will be due three weeks upon request.

C. Submittal information shall include, but not be limited to:

1. Equipment dimensions, including stub-up locations, shipping split and shipping weights.
2. Approval electrical drawings, termination drawings and component location diagrams.
3. Manufactures equipment specification.
4. Catalog cut sheets of major components.
5. Spare parts list, per Paragraph 3.03.
6. Certifications, including:
   a. Warranty, per section 1.04
   b. Efficiencies, per section 2.02. A.1.
   c. Harmonic distortion analysis study, per section 2.01E.

1.5 WARRANTY

A. All equipment furnished under this section shall be warranted for all parts and labor by the CONTRACTOR and the original equipment manufacturer for a period of not less than one (1) year from the date of startup.

B. The manufacturer shall meet the quality and program requirements of ISO 9001.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Any modification to the standard product required to meet this specification shall be performed by the VFD manufacturer or approved systems integrator only. Distributors and panel manufactures changes to the VFD products are specifically disallowed.

B. The VFD system shall consist of harmonic filter unit, input rectifier-grade phase shifting transformer (18 pulse drives only), 6 pulse converter section, output inverter and control logic. All components shall be wired and tested together as a complete system. The labor and materials for field interconnection of the system are to be provided by the VFD manufacturer. Each drive shall be designed for stand alone operation. Multiple drive units shall not utilize shared components. The drive shall be housed in a free standing, front accessible, general purpose indoor enclosure rated NEMA 1, gasketed, with fans and filters. Cabinets shall be single or multi-bay, sheet steel with hinged doors. Doors will have concealed hinges with lockable through-the-door handle operator mechanism. Provisions shall be made for top or bottom entry/exit of incoming line power cables, outgoing load cables and control wiring. All VFD’s shall include DC link reactors.

C. Each VFD shall have a molded case, circuit breaker type main power disconnect switch, with an external operating handle. The circuit breaker and the drive unit shall have a minimum short circuit rating of 42,000 amperes RMS symmetrical interrupting capacity and shall be labeled in accordance with UL Standard 489.

D. The following safety features shall be standard on all drives:

1. Provisions to padlock main disconnect handle in the “OFF” position.
2. Mechanical interlock to prevent opening cabinet door with disconnects in the “ON” position, or moving disconnect to the “ON” position while the unit door is open.
3. Auxiliary contact on main disconnects to isolate control when fed from external source.
4. Barriers and warning signs on terminals that are energized with the power disconnect “OFF”.

E. Any VFD over 10 horsepower shall meet all requirements as outlined in the latest edition of IEEE 519 for each individual and total harmonic voltage and current distortion and as indicated in this specification. As per the latest accepted IEEE 519 requirements, individual or simultaneous operation of the VFD’s shall not add more than 3% total voltage harmonic distortion while operating at full load and speed from the utility source, or more than 5% while operating from a standby generator (if applicable).

1. The VFD manufacturer cannot predict or be responsible for pre-existing voltage distortion on the line or distribution from sources supplied by others. Maximum input voltage unbalance shall be .5% as defined in NEMA MG1 section 14.35.2.
2. As per IEEE 519, maximum allowable total harmonic current demand distortion limits for each VFD operation at full load and speed shall not exceed 5% as calculated and measured at the point of common coupling Isc/Il>20).
3. The point of common coupling for all harmonic calculation and field measurement for both voltage and current distortion shall be defined as the main bus feeding each drive.
4. The short circuit current used for harmonic calculations shall be defined as the total full load current with all VFD’s operating multiplied by twenty. Example (5) 100 HP VFD’s Full load current = 5 x 126 amps = 630 amps. Short circuit current = 20x 630 amps = 12600 amps.
5. If harmonic filters are required to meet these requirements, the VFD manufacturer must provide as a minimum 5^{th}, 7^{th}, and 11^{th} harmonics filters and is responsible for the design and manufacturing of the filters. The vendor must supply cabling and installation for the filters. The filters are to be provided with a separate contactor such that the VFD can operate in the event of a filter failure. Failure of a filter shall not cause the entire drive system to shutdown.

F. Harmonic compliance shall be verified with onsite field measurement of both the voltage and current harmonic distortion on the main bus of the VFD termination without the VFD in operation. A recording of harmonic analysis displaying individual and total harmonic currents and voltage must be utilized.

G. VFD system shall maintain a 95 minimum true power factor throughout the entire speed range.

H. Displacement power factor shall be .95 percent or higher throughout the entire operating speed range, measured at drive input terminals.

I. For motors over 250hp, the drive shall include an RTD monitoring module which shall monitor 8 – 100 ohm platinum RTD’s in the motor.

J. Variable Frequency Drive Ratings:

1. The minimum drive efficiency for NEMA 1 enclosed drive shall be 95.0 percent or better at motor base speed and rated torque. Losses shall include all control power and cooling system losses associated with the drive as well as the input phase shifting transformer.
2. Input Power rating shall be 400-460VAC, plus 10 percent, minus 10 percent, 3 phase, 60 Hz, plus 2, minus 2 Hertz.
3. The voltage ride through of the VFD shall be capable of sustaining continued operation with a 40% dip in normal line voltage. Output speed may decline only if current limit rating of VFD is exceeded.
4. Power loss ride through of the VFD shall be capable of a minimum of 3 cycles loss.
5. The output power shall be HP, 460 Volt, 3 Phase, 60 Hertz, per motor nameplate FLA at installed altitude plus service factor of 25%.
6. The operating ambient Temperature -10 to 40ºC (14 to 104ºF).
7. The storage temperature shall be -20 to 60ºC (4 to 140ºF).
8. The relative operating humidity shall be 0 to 95% Non-Condensing.
9. The site operating vibration condition shall be acceleration at 0.6 G maximum (10-55 Hz). Amplitude at 0.1mm maximum (50-100 Hz).
10. Drives shall be sized/de-rated to operate at full load at an elevation of 7200 ft.
11. Power unit rating bases shall be 100% rated current continuous and 120% for one minute at rated temperature.

2.2 CONSTRUCTION

A. The controller shall produce an adjustable AC voltage / frequency output. It shall have an output voltage regulation to maintain correct output V/Hz ratio despite incoming voltage variations.

B. The controller shall have a continuous output current rating of 100% of the motor nameplate rating as a minimum.

C. The converter section will incorporate three distinct diode bridges configured in a series connection. The series connection will provide continued balance of the bridges to insure the harmonic litigation remains consistent throughout the life of the drive. The input to the diode bridges will be a full phase shifting isolation transformer with multiple secondaries. The variable frequency drive system shall also include a filter network and a transistorized inverter section. The drive manufacturer will also manufacture the Transistors used in the inverter section of the drive to reduce harmonics to flow back to the incoming power source.

D. The inverter output shall be generated by to be Insulated Gate Bipolar Transistors (IGBT's) with a PIV rating of 1200 volts minimum. The VFD shall not induce excessive power losses in the motor. The worst case RMS motor lines current measured at rated speed, torque and voltage shall not exceed 1.05 times the rated RMS motor current for a pure sin wave operation.

E. The controller (s) shall be suitable for operating standard NEMA Design-B induction squirrel-cage motor having a 1.15 service factor. The drive can be located up to 300 feet from the motor without requiring special cabling or a separate motor protection devices. Motor nameplate information shall be provided by the CONTRACTOR, prior to contract award to the VFD manufacture to properly size the inverter. In the future, is shall be possible to substitute any standard inverter rate motor (equivalent house power, voltage and RPM) in the field. Output filters shall be installed for motors over 300 foot from VFD.

F. The control logic section shall be fully digital and not require analog adjustment pots or fixed selector resistors. A power failure will not necessitate a reload of any drive parameter or configuration.

2.3 BASIC FEATURES

A. The door of each adjustable speed drive system shall include an operator interface station and key pad with a manual speed device. The interface shall be LED and have a minimum of 4 – digit, 7 – segment display. Each drive shall have a “Local”, “Remote”, “Manual” / “Auto”, “Power On”, “VFD Running” & “VFD Fault” indicating light or LED signal display. Included in the operator interface shall be a manual start, shop, bypass and fault reset button on the key pad or face of the panel.

B. The VFD shall include a customer selectable automatic restart feature. When enabled the control pad of the VFD it shall automatically attempt to auto restart after a trip condition resulting from over current, over voltage, over load, loss of utility power or out of saturation. It shall be programmable with up to 10 retrys. For safety the drive will require manual restart for other customer programmable faults. The fault displays shall include over current, over voltage, heat sink overheat, load side short circuit, load-side ground fault, inverter overload, stator over-current during start-up, load-side over current during start-up, EEPROM error, RAM error, ROM error, communication error, (Dynamic braking resistor over current), Emergency Stop, Under voltage, low current, over torque, lose of phase, and motor overload.

C. The door mounted key pad interface shall be capable of controlling the VFD and setting the drive parameters. The key pad shall have the following programming features:

1. The digital display must present all diagnostic messages and parameters values in English engineering units when accessed.
2. The digital interface keypad shall allow the operator to enter exact numerical settings in engineering units. A plain English user menu (rather than codes) shall be provided in software in nonvolatile memory as a guide to parameter setting and reset table in the field through the key pad. The drive set up parameters must be able to be transferred to new boards to reprogram spare boards.
3. The VFD shall have the capabilities of communicating via communications to the PLC or SCADA system. All status shall be communication to the PLC / SCADA including 3 phase voltage, 3 phase current, speed, status alarms, errors, etc.
4. Three programmable output relay contacts shall be rated for 250 VAC, 2 Amps. A separate 24 VDC power supply (50 mA) shall be available for control exterior control devices. Two programmable analog output signals shall be available to meet system requirements.

5. The principle output frequency shall be programmable from 0-400 Hz and acceleration / deceleration from .1 to 6000 seconds. The PWM carrier frequency shall be adjustable from .5 to 15 kHz and shall be self adjusting.
6. The VFD shall have internal to the drive a proportional gain; integral gain anti-hunting gain, lag time constant and PID error limit adjustments. This shall be programmable through the key pad.

2.4 ENCLOSURE

A. All VFD components shall be factory mounted and wired on a dead front, grounded indoor NEMA Type 1, gasketed enclosure. It shall be suitable for mounting on a concrete house keeping pad. The steel enclosure shall have a minimum of two-layer of primer and one-layer of industrial finished Sherwin Williams Precision enamel paint.

B. A forced air cooling system will automatically start and stop as necessary to extend the life of the fan.

C. VFD systems shall be stand alone system with an integral through the door mounted disconnect switch operator.

2.5 PROTECTIVE FEATURES AND CIRCUITS

A. The VFD shall have the following additional protective features that will protect against damage to the motor, load conductor, contactors or solid state soft starts and the VFD internal devices and electronics.

B. Three phase short circuit on the VFD output terminals.

C. Losses of input power due to opening VFD input disconnect device or loss of utility power during VFD operation.

D. A loss of one (1) phase of the input power shall cause the drive to trip off protecting the drive systems electronics.

E. The VFD will run without connection to the motor load.

F. The VFD shall sense an output short circuit that may occur during operation.

G. The key pad display shall provide a minimum of the last 50 system faults.

H. There shall be stall protection on an overload condition with inverse time overcurrent trip. Current limits shall be adjustable from 10 to 215% of the drive current.

2.6 PARAMETER SETTINGS

A. The following system configuring setting shall be provided and field adjustable, without exception, through the keypad/display unit. Except for motor nameplate data, all parameters must be adjustable while the processor is on-line and the drive is running.

1. Motor Nameplate Data.

2. Motor Full Load Amps.
3. Motor Frequency.
4. Number of poles.
5. Full Load RPM's.
6. Motor Voltage.
7. Operating current limits. – Min/Max.
8. VFD Configuration Parameters.
9. Independent accel/decel rates.
10. Min./Max. speed (Frequency
11. Forward or Reverse operation.
12. Catch a spinning load selection.
13. Preset Speed capabilities.
14. Volts per Hertz ratio.
15. No load / Full Load boost.
16. Over current trip selection.
17. Frequency jump selection.
18. Programmable meter output signals (Hz. Speed, RPM, Voltage, Torque, PID feed back, input/output power, and DC bus voltage.

B. Automatic Control

1. 4-20 mA input control signal.
2. PID internal or external set point capabilities.
3. Programmable preset speed operational run conditions.
4. Automatic load reduction during overload condition or soft stall.
5. Programmable loss of signal control: Stop, maintain speed or default to preset speed or set point.

C. All drive setting adjustable and operation parameters shall be restored in a parameter log which allows minimum and maximum points as well as the present set values. This parameter log shall be accessible via a RS-232 or RS485 serial port as well on the keypad or internal to the drive.

D. The drive shall have the following inputs/output features that will provide control and monitoring of the VFD. The analog outputs shall be isolated as required by this specification.

1. Three programmable analog outputs.
2. Two programmable analog inputs. The 4-20mA analog input speed reference signal will be galvanically isolated. Calibration adjustments shall be provided by the keypad.
3. 4-groups of 8 pattern runs or 32 pattern runs shall be available.
4. Three programmable digital output (form C, dry contact relays)
5. One potential pot input (three wire control) +10 V, wiper and common.
6. System control program providing built–in drive control or application specific configuration capabilities.
7. One system E-stop input (dry contact) cost to stop.
8. Input / output function shall match those indicated in the drawings.
9. Minimum / maximum dry contact output.

2.7 DIAGNOSTIC FEATURES AND FAULT HANDLING

A. The VFD shall include a comprehensive microprocessor based digital diagnostic system that monitors its own control functions and displays faults and operating conditions.

B. A “Fault Log” shall be accessible through the keypad digital illustrations in English. The display shall be capable of illustrating 50 past faults. Optional output shall be through the serial port link. All drive possible fault conditions will be accessible through the fault log.

2.8 DRIVE OPTIONS

A. For drives located more then 300 feet from motor, the drive shall be modified to include a factory or SI wired output line reactor.

B. Information included elsewhere:

1. Drive feed location – See Drawings.
2. Drive overall dimensions allowed – See Drawings.
3. Additional control information – See Drawings.

PART 3 EXECUTION

3.1 FACTORY TESTING

A. The drives will be completely assembled, wired, and tested in the United States of America. The following tests will be performed:

1. The manufacturer shall use the ISO-9001 standards in the purchase, engineering, manufacturing and testing of the VFD system.
2. Upon completion of manufacture and assembly, the drives shall be subjected to a complete factory test to demonstrate compliance with specified features and characteristics of the specification. The purchaser at his option shall be able to witness factory testing of his unit, with factory coordination.
3. The testing procedure shall be the manufacturer’s standard procedure (except for loss of phase) to assure maintenance free service. The buyer shall be given a 5 day notice prior to the start of factory testing for the buyer's representative to witness the testing.
4. All equipment, devices, instrumentation, and personnel required to perform the factory tests shall be supplied by the manufacturer. Upon satisfactory completion of the test, the seller shall upon request submit two (2) certified copies of the test report to the buyer. Component failure during testing will require repeating any test associated with the failure or modified components to demonstrate proper operation.
5. A loss of each phase testing shall be conducted at the factory to guaranty the safe and orderly shutdown of the drive under load. These tests shall conclude that the drive will not fail its electronic circuits or causes sever over heating of the bridges. These tests shall not limit the life of the drive system. There are no exceptions to this test. This test shall be performed and test reports provided to the ENGINEER prior to installation of the drive system package.

3.2 STARTUP AND FIELD TESTING

A. The VFD manufacturer shall provide the services of a factory trained technician for startup assistance, programming and testing. Verification of the VFD input harmonics voltage and current distortion limits specified must be verified as part of the start-up and acceptance. If harmonics distortion requirements are not met, it is the responsibility of the VFD supplier to meet these specifications at the manufacturer's expense. Meg-ohm testing will be done to the load conductors and motor to verify condition of the equipment prior to startup. The VFD manufactures shall certify the VFD and motor system as compatible. UL508 technicians shall not be allowed to perform startup procedures.

B. A 10% payment retention will be released upon factory field test verification of harmonic specifications requirements and final test report and acceptance.

C. Spare Parts

1. The following spare parts shall be furnished. The net price per item shall be provided with the request for proposal. Each spare part shall be package and identified by part number and type for long term customer storage.
   a. Three of each type of fuse rated 480 Volts or less.
   b. Two of each type of converter power semi-conductor.
   c. Two of each type of inverter power semi-conductor.
   d. One of each type of control board, gate firing board and communication board.
   e. One key pad assembly.
   f. Five of each type of panel lamp.
   g. Three of each size MOV's.

- END OF SECTION -

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SECTION 26 32 00
STANDBY ENGINE GENERATOR

PART 1 GENERAL

1.1 DESCRIPTION OF SYSTEM

A. Provide a standby power system to supply electrical power in event of failure of normal supply, consisting of a liquid cooled engine, an AC alternator, system controls, and sound attenuated enclosure with all necessary accessories for a complete operating system, including but not limited to the items as specified hereinafter.

B. Provide an automatic transfer switch, specified elsewhere, as part of a packaged system such that the system comes on-line fully automatically, and on restoration of utility power automatically retransfers load to normal power, shuts down the generator and returns to readiness for another operating cycle.

1.2 REQUIREMENTS OF REGULATORY AGENCIES

A. Conform to N.E.C. and applicable inspection authorities.

B. Transfer switch(s) to be labeled under UL 1008 and shall be programmed by a factory trained and authorized representative.

1.3 MANUFACTURER QUALIFICATIONS

A. These systems shall be supplied by a manufacturer who has been regularly engaged in the production of engine-alternator sets, automatic transfer switches, and associated controls for a minimum of fifteen years, thereby identifying one source of supply and responsibility.

B. To be classified as a manufacturer, the builder of the generator set must manufacture at minimum engines or alternators.

C. The manufacturer shall have printed literature and brochures describing the standard series specified, not a one of a kind fabrication.

D. Manufacturers:

1. Caterpillar
2. Cummins
3. Kohler
4. Generac

E. Substitutes: Proposed substitutions shall include complete submittal data, as specified herein and required elsewhere, clearly denoting and all deviations and/or exceptions to the equipment specified. The complete proposed substitution must be submitted in accordance with the Standard General Conditions and Supplementary Conditions.

1.4 WARRANTY

A. The standby electric generating system components, complete engine-generator and instrumentation panel shall be warranted by the manufacturer against defective materials and factory workmanship for a period of 36 months or 3,000 hours, whichever is greater. This warrantee shall include freight, shipping, labor, parts, etc. for the entire generation system. Such defective parts shall be repaired or replaced at the manufacturer's option, free of charge for travel and labor. An additional 4 years of the manufacturer's standard warranty coverage shall be provided. The warranty period shall commence when the standby power system is first placed into service. Multiple warranties for individual components (engine, alternator, controls, etc.) will not be acceptable. Satisfactory warranty documents must be provided. Also, in the judgment of the specifying authority, the manufacturer supplying the warranty for the complete system must have the necessary financial strength and technical expertise with all components supplied to provide adequate warranty support.

1.5 SUBMITTALS

A. Provide complete sets of Engineering Submittal for approval, prior to production release, showing all components, in addition to the engine and generator. Submittals shall skow compliance with these specifications.

B. Provide sizing calculations showing the submitted units ratings at altitude and ambient temperature.

C. Refer to Sections 01 30 00 and 26 05 00 for additional submittal requirements.

PART 2 PRODUCTS

2.1 ENGINE

A. The prime mover shall be a liquid cooled, Diesel engine of 4-cycle design. The unit requires a minimum rated output as specified in these documents.

B. The engine is to be cooled with a unit mounted radiator, fan, water pump, and closed coolant recovery system providing visual diagnostic means to determine if the system is operating with a normal engine coolant level. The radiator shall be designed for operation in the ambient temperature conditions listed in this document. Fan and radiator shall be sized for the critical grade sound attenuated enclosure of the generator.

C. The intake air filter with replaceable element must be mounted on the unit. Full pressure lubrication shall be supplied by a positive displacement lube oil pump. The engine shall have a replaceable oil filter with internal bypass and replaceable elements. Engine coolant and oil drain extension must be provided to outside of the mounting base for cleaner and more convenient engine servicing. A fan guard must be installed for personnel safety.

D. The engine shall have a battery charging DC alternator with a transistorized voltage regulator. Remote 2-wire starting shall be by a solenoid shift, electric starter.

E. Engine speed shall be governed by electronic governor to maintain alternator frequency within .5% from no load to full load alternator output. Steady state regulation is to be 0.25%.

F. The engine fuel system shall be designed for operation with Diesel fuel. A fuel shutoff solenoid and all fuel lines must be installed at the point of manufacture.

G. Sensing elements to be located on the engine for low oil pressure shutdown, high coolant temperature shutdown, low coolant level shutdown, overspeed shutdown and overcrank protection. These sensors are to be connected to the control panel using a wiring harness with the following features: wire number labeling on each end of the wire run for easy identification, a molded rubber boot to cover the electrical connection on each sensor to prevent corrosion and all wiring to be run in flexible conduit for protection from the environment and any moving objects.

H. Engine Manufacturers:

1. Caterpillar
2. Cummins
3. John Deere
4. GM
5. Perkins
6. Volvo
7. Generac

2.2 CAPABILITY REQUIREMENTS

A. Generators shall have the following operation capabilities:

	Generator No. 1
B. Site Rated kW rating	600 kW @ 0.8 Power Factor
C. Fuel -	Diesel
D. Voltage-	480/277, Parallel Wye
E. Phase -	Three (3)
F. Frequency (Hz)	60
G. Altitude -	4250 feet
H. Ambient Temperature	-30 degrees F to 110 degrees F.

I. Main Breaker, Solid State with GFP, 100% Rated – Sizes as indicated on the drawings.

2.3 FACTORY INSTALLED EQUIPMENT

A. Generator Set(s) shall have solid state controller(s) as standard. Controls shall be factory installed and tested. Controllers shall be reliable, durable and accurate, have easy to read meters. Three spare inputs and one spare output shall be provided for customer programmed set points. Controller shall use an SAE format, the panel shall

zero in on the affected system and identify the component responsible for the failure. Key-pad programmable set points, following items shall be standard features of controller:

1. Digital (LCD) Indication
    a. AC Voltage (L-L)
    b. AC amps
    c. System Diagnostics
    d. Frequency
    e. DC Voltage
    f. Coolant Temperature
    g. Oil Pressure
    h. RPM
    i. Hours Run
2. Controls
    a. Auto Start/Stop
    b. Emergency Stop
    c. Lamp Test
    d. Cycle Crank
    e. Voltage Control
    f. Cooldown Timer
    g. Phase Selector Switch
3. Indicating Lights
    a. Low Oil Pressure
    b. High Coolant Temperature
    c. Overspeed
    d. Overcrank
    e. Emergency Stop
    f. Fault Shutdown *
    g. Fault Alarm *
    h. Not in auto
    i. Pre-Alarm
        1) 1 Spare Inputs – Customer Programmable

B. A heavy duty, lead acid battery set shall be provided by the generator set manufacturer of adequate voltage and amperage capacity to start and operate the engine. Provide all intercell and connecting battery cables as required.

C. The manufacturer shall supply and install its recommended stainless steel, flexible connector to couple the engine exhaust manifold to the exhaust system.

D. The engine shall have a unit mounted, thermostatically controlled water jacket heater to aid in quick starting. It will be of adequate wattage as recommended by the engine manufacturer. The contractor shall provide proper branch circuit from normal utility power source.

E. An oil heater and thermostat shall be installed in the engine oil pan at the factory as recommended by manufacturer.

F. A block heater and thermostat shall be installed in the engine block at the factory as recommended by manufacturer.

G. Provide a thermostatically controlled blanket type battery heater to increase engine battery capacity for cold weather starting.

H. Provide an automatic dual rate battery charger manufactured by the engine-generator set supplier. The automatic equalizer system shall monitor and limit the charge current to 10 amps. The output voltage is to be determined by the charge current rate. The charger must have a maximum open circuit voltage of 35 volts and be protected against a reverse polarity connection. The battery charger is to be factory installed on the generator set. Due to line voltage drop concerns, a battery charger mounted in the transfer switch will be unacceptable.

2.4 THE FOLLOWING EQUIPMENT IS TO BE PROVIDED BY THE ENGINE-GENERATOR SET MANUFACTURER AND SHIPPED LOOSE WITH THE UNIT:

A. The manufacturer will supply its recommended flexible fuel line to connect the engine to the external fuel source. On stationary applications the fuel line shall match the fuel fitting on the unit base rail and have braided stainless steel covering with brass fittings.

B. Installation acceptance test to be conducted on-site shall include a “cold start” test, a six-hour full load test, and a on-step rated load pickup test in accordance with NFPA 110. Provide a resistive load bank for 100% rated load and make temporary connections for full load test.

2.5 ALTERNATOR

A. The alternator shall be a 4-pole revolving field type, 12 lead, wired for or 277/480 VAC, three phase, 60 Hz with a brushless, PMG exciter. Photosensitive components will not be permitted in the rotating exciter. The stator shall be direct connected to the engine to insure permanent alignment. The generator shall meet temperature rise standards for Class "H" insulation; operate within Class "F" standards for extended life. All leads must be extended into an AC connection panel. The alternator shall be protected by internal thermal overload protection and an automatic reset field circuit breaker.

B. One step load acceptance shall be 100% of nameplate rating and meet the requirements of NFPA 110 paragraph 5-13.2.6. The generator set and regulator must sustain at least 90% of rated voltage for 10 seconds with 250% of rated load at near zero power factor connected to its terminals when equipped with direct or brushless excitation. 300% short circuit current must be selectable on units equipped with permanent magnet exciters. Generators equipped with permanent magnet exciters not allowing the selection of the short circuit current ratings are not allowed.

C. A solid state voltage regulator designed and built by the engine-generator set manufacturer must be used to control output voltage by varying the exciter magnetic field to provide + or - 1% regulation during stable load conditions. Should an extremely heavy load drop the output frequency, the regulator shall have a voltage droop of 4 Volts/Hertz to maximize motor starting capability. The frequency at which this droop operation begins must be adjustable, allowing the generator set to be properly matched to the load characteristics insuring optimum system performance. Additional rheostats for matching generator voltage, droop, and stability characteristics to the specific load conditions must be available.

D. The voltage regulator must contain a limiting circuit to prevent output voltage surges in excess of 125% of rated voltage during generator set operation. On loss or near loss of the voltage sensing signal, the voltage regulator must be capable of shutting down to prevent an overvoltage condition from occurring. It must have a second mode of operation allowing 300% of rated current to flow through the electrical distribution circuit(s) for ten (10) seconds under the same conditions. Voltage regulators not capable of selecting either mode of operation are not acceptable. LED indication will be provided on the regulator to monitor the sensing (yellow), excitation (green), and output circuit (red).

E. A NEMA 1 panel that is an integral part of the generator set must be provided to allow the installer a convenient location in which to make electrical output connections. An isolated neutral lug must be included by the generator set manufacturer to insure proper sizing.

2.6 MOUNTING

A. The electric plant shall be mounted with vibration isolators on a welded steel base that shall permit suitable mounting to any level surface.

2.7 PROVIDE FOLLOWING ITEMS INSTALLED AT FACTORY

A. The unit mounted main line circuit breaker shall have an internal set of form "C" contacts that change state whenever the breaker is opened or closed. Lamps on the generator control panel shall indicate breaker position and screw terminals in the control panel shall provide appropriate system DC voltage for remote annunciation.

B. A solid state, thermal magnetic UL listed main line circuit breaker shall be mounted in the AC connection panel. The line side connections are to be made at the factory. A system utilizing a manual reset field circuit breaker and current transformers is unacceptable.

2.8 CONTROLS

A. All engine alternator controls and instrumentation shall be designed, built, wired, tested and shock mounted in a NEMA 12 enclosure to the engine-generator set by the manufacturer. It shall contain panel lighting, a fused DC circuit to protect the controls and a +/-5% voltage adjusting control. This panel must be able to be rotated 90 degrees in either direction for correct installation.

B. The engine-generator set shall contain a complete 2 wire automatic engine start-stop control which starts the engine on closing contacts and stop the engine on opening contacts. A cyclic cranking limiter shall be provided to open the starting circuit after eight attempts if the engine has not started within that time. Engine control modules must be solid state plug-in type for high reliability and easy service. The engine controls shall also include a 3-position selector switch with the following positions: AUTO/OFF/RUN. Auto will allow full automatic operation, off disables any engine start, run starts the engine. An emergency stop switch, panel fuse, 5% voltage adjust rheostat and RS485 communications port shall be panel mounted.

C. A micro-processor based digital control panel will be supplied. It shall simultaneously display all operating conditions including:

1. AC Volts
2. AC Amperes
3. Frequency
4. Power Factor
5. KW Output
6. Oil Pressure
7. Water Temperature
8. Fuel level (where applicable)
9. Battery Voltage
10. Run Time Hours. It shall have individual LED's to indicate:
    a. Selected Phase
    b. High or Low AC Voltage
    c. High or Low Battery Voltage
    d. High or Low Frequency
    e. Low and Pre-Low Oil Pressure
    f. Low Water level
    g. Low Water Temperature
    h. High and Pre-High Engine Temperature
    i. High, Low and Critically Low Fuel Levels and Fuel in Rupture Basin(where applicable)
    j. Emergency Stop
    k. Overcrank
    l. Overspeed
    m. Unit not in Automatic Mode
    n. Status of Main Line Circuit Breaker(where applicable)
    o. Program Mode
11. Two additional LED's for future programming. A keypad shall allow local programming of the units operating parameters as well as testing and resetting of the alarm LED's. The keypad shall include the phase selector function.

D. The following equipment is to be installed at the engine-generator set manufacturer's facility:

1. A red mushroom type emergency stop switch shall be mounted on the generator control panel and when pressed shall shutdown the engine/generator requiring a manual reset before operation can resume.
2. A sensor shall be installed in the sub-base fuel tank indicating 50% of fuel remaining. A "Low Fuel" lamp on the control panel and on the remote annunciator will illuminate when this level is reached. The alarm shall be available to the PLC

2.9 UNIT ACCESSORIES

A. Generator set housing shall be provided factory-assembled to generator set base and radiator cowling. Housing shall provide ample airflow for generator set operation at rated load in the ambient conditions previously specified. The housing shall have hinged side-access doors an rear control door. All doors shall be lockable. All sheet metal shall be primed for corrosion protection and finish painted with the manufacturer’s standard color using a two step electrocoating paint process, or equal meeting the performance requirements specified below. All surfaces of all metal parts shall be primed and painted. The painting process shall result in a coating which meets the following requirements:

1. Primer Thickness, 0.5-2.0 mils

2. Top Coat Thickness, .08-1.2 mils
3. Gloss, per ASTM D523-89, 80% plus or minus 5%. Gloss retention after one year shall not exceed 50%
4. Crosshatch Adhesion, per ASTM D3359-93, 4B-5B
5. Impact Resistance, per ASTM D2794-93, 120-160 inch pounds
6. Salt Spray, per ASTM B117-90, 1000+ hours
7. Humidity, per ASTM D2247-92, 1000+ hours
8. Water Soak, per ASTM D2247-92, 1000+ hours

B. Painting of hoses, clamps, wiring harnesses, and other non-metallic service parts shall not be acceptable. Fasteners used shall be corrosion resistant and designed to minimize marring of the painted surface when removed for normal installation or service work.

C. The generator set shall be provided with sound-attenuated housing which allows the generator set to operate at full rated load in the ambient conditions previously specified. The enclosure shall reduce the sound level of the generator set while operating at full rated load to a maximum of 72 dB(A) 7 meters from the nearest point of the proposed generator installation location. Housing configuration and materials used may be of any suitable design which meets application needs, except that acoustical materials used shall be oil and water resistant. No foam materials shall be used unless they can be demonstrated to have the same durability and life as fiberglass. The engine-generator set shall be factory enclosed in a 12 gauge steel enclosure constructed with corner posts, uprights and headers. The roof shall aid in the runoff of water and include a drip edge. The enclosure shall be coated with electrostatically applied power paint, baked and finished to manufacturer's specifications. The enclosure shall be completely lined with 1" thick minimum, UL 94 HF-1 listed, sound deadening material. This material must be of a self extinguishing design. The enclosure is to have large, hinged, removable doors to allow access to the engine, alternator and control panel. Hinges and all exposed fasteners will be stainless steel. Each door will have lockable hardware with identical keys. Padlocks do not meet this specification. The critical silencer shall be mounted within the enclosure to further reduce the unit sound level and provide a clean, smooth exterior design. The enclosure shall include sound insulated, baffled air intake hoods and air exhaust hoods. The generator set shall be sized to account for losses in sound baffles and critical grade appurtenances.

D. The following equipment is to be provided by the engine-generator set manufacturer:

1. Spring type vibration isolators to mount between the engine mounting base and fuel tank frame to eliminate noise, reduce transmitted vibration and provide earthquake protection.

E. Provide a dual wall sub base fuel tank with day tank fuel level controls.

1. The sub base fuel tank will contain 72 hours of diesel fuel to support the generator set for a period of 72 hours at full load. The sub base fuel tank shall be listed under UL 142, sub section entitled "Special Purpose Tanks EFVT" category, and will bear their mark of "UL Approval" according to their particular classification.
2. Secondary Containment Generator Base Tank:

a. Aboveground steel secondary containment rectangular tank for use as a sub base for diesel generators intended to be installed in accordance with the standards of NFPA 30, 37 & 110. These tanks have provisions for monitoring the annular (containment) space for leakage. (Both the inner and outer containment tanks must provide for emergency venting per NFPA 30.).
b. Rectangular, heavy gauge, welded steel construction.
c. Double wall with a sealed, separately vented, integral fuel containment basin.
d. Reinforced steel box channels for generator support.
e. Full height gussets provided at genset mounting holes.
f. Interior coated with a solvent-based rust inhibitor.
g. Top-mounted fuel gauge.
h. Engine fuel supply and return drop tubes.
i. Day tank supply and return drop tubes.
j. Raised fuel fill.
k. Mounting brackets for optional pump and control.
l. Ground clearance to minimize bottom rusting.
m. Integral lifting points.
n. Tanks are leak-checked to ensure integrity of weld seams prior to shipment.

3. Ancillary Equipment:
   a. The base tank will be equipped with accessories required for the application and by NFPA 30 for this application. The accessories shall include but not be limited to:
      1) Low fuel level float switch, set at 10% level.
      2) High fuel level / overfill prevention, audible alarm, set at 90% level.
      3) Overfill prevention float valve or solenoid on tank fill port, set at 95% level.
      4) Fill port drop tube to within 6” of the bottom of the tank.
      5) Spill containment bucket or basin around fill port.
      6) Interstitial monitoring float switch (leak detection).
      7) Normal vents, extended 12 feet above grade, flame arrester caps.
      8) Emergency vents, on tank and containment basin.
      9) Provisions for connection of grounding conductor.
      10) Tank calibration chart in inches to gallons.
      11) Warning Signage; No Smoking, Flammable Liquids, Diesel Fuel, NFPA 704 Placards.
      12) Fuel level transmitter (4-20mA)
4. The tank shall include independent level sensors and remote dry contacts for a critical high fuel shutdown. The alarm condition activates a red light on tank control panel, coils on a relay for remote annunciation and closes a normally open solenoid valve in the fuel inlet piping.
5. All alarms and level controls shall be factory assembled and wired so that only a 115 VAC power supply need be applied to make the tank control system functional. The remote alarm dry contacts will require separate wiring and power supply.
6. A fuel strainer shall be provided and installed up stream of all solenoid valves in the fuel inlet piping.

F. PLC Monitoring Systems:

1. Provide a monitoring system interface within the generator capable of communicating via Modbus TCP all generator parameters and alarms to the PLC.

PART 3 EXECUTION

3.1 FACTORY TESTING

A. Before shipment of the equipment, the engine-generator set shall be tested under rated load for performance and proper functioning of control and interfacing circuits. Tests shall include:

1. Verifying all safety shutdowns are functioning properly.
2. Single step load pick-up per NFPA 110, Paragraph 5-13.2.6.
3. Transient and voltage dip responses and steady state voltage and speed (frequency) checks.

3.2 OWNER'S MANUALS

A. Three (3) sets of OWNER's manuals specific to the product supplied must accompany delivery of the equipment. General operating instruction, preventive maintenance, wiring diagrams, schematics and parts exploded views specific to this model must be included.

3.3 INSTALLATION

A. CONTRACTOR shall install the complete electrical generating system including all fuel connections in accordance with the manufacturer's recommendations as reviewed by the ENGINEER.

B. CONTRACTOR to supply all lugs required for external load connections.

3.4 SERVICE

A. Supplier of the electric plant and associated items shall have permanent service facilities in this trade area. These facilities shall comprise a permanent force of factory trained service personnel on 24 hour call, experienced in servicing this type of equipment, providing warranty and routine maintenance service to afford the OWNER maximum protection. Delegation of this service responsibility for any of the equipment listed herein will not be considered fulfillment of these specifications. Service contracts shall also be available.

3.5 STARTUP AND CHECKOUT

A. The supplier of the electric generating plant and associated items covered herein shall provide factory trained technicians to checkout the completed installation and to perform an initial startup inspection to include:

1. Engine Generator/ATS Testing: See Section 17100 for requirements
   a. Low-voltage cable insulation integrity tests shall be performed for cables connecting the generator breaker to the panelboard. Low-voltage cable, complete with splices, shall be tested for insulation resistance after the cables are installed, in their final configuration, ready for connection to the equipment. The test voltage shall be 100 volts dc, applied for 30 seconds between each conductor and ground and between all possible combinations conductors in the same trench, duct, or cable, with all other conductors in the same trench, duct, or conduit. The minimum value of insulation shall be:
   b. R in megohms = (rated voltage in kV + 1) x 304,800/(length of cable in meters)
   c. R in megohms = (rated voltage in kV + 1) x 1000/(length of cable in feet)

d. Each cable failing this test shall be repaired or replaced. The repair cable shall be retested until failures have been eliminated.

2. Circuit breakers and switchgear shall be examined and tested in accordance with the manufacturer's published instructions for functional testing.

B. Inspections

C. The following inspections shall be performed jointly by the Contractor, after complete installation of each engine-generator set and its associated equipment, and prior to startup of the engine-generator set. Checks applicable to the installation shall be performed. The results of those which are physical inspections (I) shall be documented by the Contractor and submitted in accordance with paragraph SUBMITTALS. The Contractor shall present manufacturer's data for the inspections designated (D) at the time of inspection. Inspections shall verify that equipment type, features, accessibility, installation and condition are in accordance with the contract specification. Manufacturer's statements shall certify provision of features which cannot be verified visually.

1. Drive belts.
2. Governor type and features.
3. Engine timing mark.
4. Starting motor.
5. Starting aids.
6. Coolant type and concentration.
7. Radiator drains.
8. Block coolant drains.
9. Coolant fill level.
10. Coolant line connections.
11. Coolant hoses.
12. Combustion air filter.
13. Intake air silencer.
14. Lube oil type.
15. Lube oil sump drain.
16. Lube-oil filter.
17. Lube-oil level indicator.
18. Lube-oil fill level.
19. Lube-oil line connections.
20. Lube-oil lines.
21. Fuel type.
22. Fuel-level. (where applicable)
23. Fuel-line connections.
24. Fuel lines.
25. Fuel filter.
26. Access for maintenance.
27. Voltage regulator.
28. Battery-charger connections.
29. Wiring & terminations.
30. Instrumentation.
31. Hazards to personnel.
32. Base.
33. Nameplates.
34. Paint.

35. Exhaust-heat system.
36. Exhaust muffler.
37. Switchboard.
38. Switchgear.
39. Access provided to controls.
40. Enclosure is weather resistant.
41. Engine & generator mounting bolts (application).

D. Performance Tests

1. In the following tests, where measurements are to be recorded after stabilization of an engine-generator set parameter (voltage, frequency, current, temperature, etc.), stabilization is considered to have occurred when measurements are maintained within the specified bandwidths or tolerances, for a minimum of four consecutive readings. For the following tests, if any parts are changed, or adjustments made to the generator set, its controls, or auxiliaries, the associated tests shall be repeated.
   a. Continuous Engine Load Run Test:
      1) Test the engine-generator set and ancillary systems at service load to demonstrate durability; verify that heat of extended operation does not adversely affect or cause failure in any part of the system; and check all parts of the system. If the engine load run test is interrupted for any reason, the entire test shall be repeated. After each change in load in the following test, measure the vibration at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Verify that the vibration is within the allowable range. Data taken at 15 minute intervals shall include the following:
      2) Electrical: Output amperes, voltage, real and reactive power,
      3) power factor, frequency.
      4) Pressure: Lube-oil.
      5) Temperature: Coolant, Lube-oil, Exhaust, Ambient.
         (a) Perform and record engine manufacturer's recommended prestarting checks and inspections. Include as a minimum checking of coolant fluid, fuel, and lube-oil levels.
         (b) Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warmup period.
         (c) Operate the engine generator-set for 2 hours at 75% of Service Load.
         (d) Increase load to 100% of Service Load and operate the engine generator-set for 4 hours.
2. Verify that the engine-generator set responds to addition and dropping of blocks of load in accordance with the transient response requirements. Document maximum voltage and frequency variation from bandwidth and verify that voltage and frequency return to and stabilize within the specified bandwidth, within the specified response time period. Document results in tabular form and with high resolution, high speed strip chart recorders or comparable digital recorders, as approved by the Contracting Officer.
   a. Tabular data shall include the following:
   b. Ambient temperature (at 15 minute intervals).
   c. Generator output current (before and after load changes).
   d. Generator output voltage (before and after load changes).
   e. Frequency (before and after load changes).

f. Generator output power (before and after load changes.
g. Graphic representations shall include the actual instrument trace of voltage and frequency showing:
    1) Charts marked at start of test; observed steady-state band; mean of observed band; momentary overshoot and undershoot (generator terminal voltage and frequency) and recovery time for each load change together with the voltage and frequency maximum and minimum trace excursions for each steady state load condition prior to and immediately following each load change. Generator terminal voltage and frequency transient recovery time for each step load increase and decrease.
        a) Perform and record engine manufacturer's recommended prestarting checks and inspections.
        b) Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period and no load. Verify stabilization of voltage and frequency within specified bandwidths.
        c) With the unit at no load, apply the Maximum Step Load Increase.
        d) Apply load in steps equal to the Maximum Step Load Increase until the addition of one more step increase will exceed the Service Load.
        e) Decrease load to the unit such that addition of the Maximum Step Load Increase will load the unit to 100% of Service Load.
        f) Apply the Maximum Step Load Increase.
        g) Decrease load to zero percent in steps equal to the Maximum Step Load Decrease.
        h) Repeat steps c. through g.

E. Generator Fail Test:

1. Test the capability of each engine-generator set to pick up the entire load if the alternate generator fails. During operations record load-sharing characteristics of each set in parallel operation. Data taken shall include the following:
    a. Ambient temperature (at 15 minute intervals).
    b. Generator output current (before and after load changes).
    c. Generator output voltage (before and after load changes).
    d. Power division and exchange between generator sets.
    e. Real power (watts) and reactive power (vars) on each set.
2. Combinations
    a. Connect each set, to the load of the system, operating at service load, until all possible two-unit-in-parallel combinations have been achieved. Verify stabilization of voltage and frequency within specified bandwidths and proportional sharing of real and reactive loads. Document stabilization of voltage and frequency within specified bandwidth, and voltage and frequency stability and transient response in the following steps for each combination.

F. Automatic Operation Tests for Engine Generator Set:

1. The automatic operating system shall be tested to demonstrate automatic starting, the response to loss of operating engine-generator sets, and paralleling of each engine-generator set. The loads for this test shall utilize actual loads to be served, and the loading sequence shall be the indicated sequence. Perform this test for a minimum of two successive, successful tests. Data taken shall include the following:
    a. Ambient temperature (at 15 minute intervals).
    b. Generator output current (before and after load changes).
    c. Generator output voltage (before and after load changes).

d. Generator output frequency (before and after load changes).
e. Power of each generator set.
f. Real and reactive power on each set.

2. Initiate loss of the preferred power source and verify the specified sequence of operation.
3. Verify resetting of automatic starting and transfer logic.

G. Automatic Operation Tests for Stand-Alone Operation

1. The automatic loading system shall be tested to demonstrate automatic starting, of each engine-generator set. The loads for this test shall utilize the actual loads to be served, and the loading sequence shall be the indicated sequence. Perform this test for a minimum of two successive, successful tests. Data taken shall include the following:
   a. Ambient temperature (at 15 minute intervals).
   b. Generator output current (before and after load changes).
   c. Generator output voltage (before and after load changes).
   d. Generator output frequency (before and after load changes).
      1) Initiate loss of the primary power source and verify automatic sequence of operation.
      2) Restore the primary power source and verify sequence of operation.
      3) Verify resetting of controls to normal.

H. Pull the Plug System Test:

1. The contractor shall record all voltages and frequencies prior to and after each sequence of the test.
2. Contractor shall simulate a power outage by opening all circuit breakers which feed automatic transfer switches. The contractor shall then observe that the engines generators start up and run and that the transfer switches take the load. Time delays for start up and transfers of each transfer switch shall be recorded. The contractor shall verify proper operation of each automatic transfer switch.
3. Contractor shall verify proper startup and operation of all equipment including fans, pumps, chillers, alarm and monitoring systems and lighting systems.
4. Contractor shall verify proper operation of lighting systems to insure that emergency lighting has returned. Contractor shall verify the proper operation of each fan coil unit.
5. The contractor shall verify proper operation of each UPS to insure that power to critical loads was not interrupted.
6. The contractor shall then restore power to transfer switches by closing each of these breakers and verifying that all systems time out and retransfer, that generators cool down and subsequently shut off. All time delays shall be recorded.
7. Contractor shall then verify proper restart of all equipment as noted above.
8. Contractor shall then verify that each UPS maintained power to the critical load during the retransfer.
9. Contractor shall then verify that all lighting and non UPS systems return to normal operation.

- END OF SECTION -

SECTION 26 33 00
STATIC UN-INTERRUPTIBLE POWER SUPPLY

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:

B. Stand alone cord and plug connected UPS systems.

C. Provide one shelf mounted UPS in each PLC cabinet (PLC-A, PLC-B, PLC-SH, PLC-FE).

D. Provide one UPS for each computer system (SCADA, Historian Server, HMI Directory Server).

1.2 APPLICABLE SECTIONS

A. The General Conditions, Supplementary General Conditions, alternates and Addenda,

B. applicable drawings and the technical specification including but not limited to the following:

1. Section 26 05 00 - Electrical General Requirements.
2. Section 26 05 19 – 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 26 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 26 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 26 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 26 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 26 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 26 35 53
SURGE PROTECTION DEVICES

PART 1 GENERAL

1.1 SCOPE

A. 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:

1.2 RELATED SECTIONS

A. Section 16426A – Metal Enclosed Draw out Switchgear (Magnum DS) – Low Voltage

B. Section 16426B – Metal Enclosed Draw out Switchgear (DSII) – Low Voltage

C. Section 16428 – Switchboards – Low Voltage (Compartmentalized Feeders – Pow-R-Line *i*)

D. Section 16429 – Switchboards – Low Voltage (Group Mounted Feeders – Pow-R-Line C)

E. Section 16431 – Switchboards – Low Voltage (Commercial Metering)

F. Section 16466 – Busway – Low Voltage

G. Section 16470 – Panelboards

H. Section 16482A & B – Motor Control Centers – Low Voltage (Freedom and Advantage)

1.3 REFERENCES

A. SPD units and all components shall be designed, manufactured, and tested in accordance with the latest applicable standards

1. ANSI/UL 1449 4th Edition or later
2. ANSI/UL 1283 5th Edition or later (type 2 applications)
3. IEEE C62.41.1
4. IEEE C62.41.2
5. IEEE C62.43-2005
6. IEEE C62.45-2002
7. IEEE C62.48-2005
8. IEEE C62.62-2010
9. UL 96A
10. NFPA 780

1.4 SUBMITTALS – FOR REVIEW/APPROVAL

A. The following information shall be submitted to the Engineer:

1. 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).

B. Where applicable the following additional information shall be submitted to the engineer:

1. Descriptive bulletins
2. Product sheets

1.5 SUBMITTALS – FOR CONSTRUCTION

A. The following information shall be submitted for record purposes:

1. Final as-built drawings and information for items listed in Section 1.04 and shall incorporate all changes made during the manufacturing process

1.6 QUALIFICATIONS

A. The manufacturer of the electrical distribution equipment shall be the manufacturer of the SPD within the electrical distribution equipment.

B. For the equipment specified herein, the manufacturer shall be ISO 14001 and ISO 9001 or 9002 certified.

C. 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.

D. The SPD shall be compliant with the Restriction of Hazardous Substances (RoHS) Directive 2011/65/EU and have a visible label showing compliance.

E. 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.

1.7 DELIVERY, STORAGE AND HANDLING

A. 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.

1.8 OPERATION AND MAINTENANCE MANUALS

A. Operation and maintenance manuals shall be provided with each SPD shipped.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Eaton or prior approved equal.

B. 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.

2.2 VOLTAGE SURGE SUPPRESSION – GENERAL

A. Electrical Requirements

1. Unit Operating Voltage – Refer to drawings for operating voltage and unit configuration.
2. Maximum Continuous Operating Voltage (MCOV) – The MCOV shall not be less than 115% of the nominal system operating voltage.
3. 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.
4. 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.
5. 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	●	●	●	●

6. 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.
7. 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

B. SPD Design

1. 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.
2. 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.
3. 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.
4. 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.
5. 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.
      1) 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.
      2) 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
      3) 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.

4) 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.

6. Thermal MOV Protection
   a. 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.
7. 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.
8. Safety Requirements
   a. 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.
   b. 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.

2.3 SYSTEM APPLICATION

A. 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.

B. 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

2.4 THE COMPLETE PANELBOARD LIGHTING AND DISTRIBUTION REQUIREMENTS

A. 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.

B. The SPD shall not limit the use of through-feed lugs, sub-feed lugs, and sub-feed breaker options.

C. 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.

D. The panelboard shall be capable of re-energizing upon removal of the SPD.

E. 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.

F. The SPD shall be included and mounted within the panelboard by the manufacturer of the panelboard.

G. The SPD shall be of the same manufacturer as the panelboard.

H. including the SPD shall be UL67 listed.

2.5 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.

2.6 SERVICE ENTRANCE REQUIREMENTS

A. Service entrance located SPDs shall be tested and designed for applications within ANSI/IEEE C62.41 Category C environments. EXECUTION.

2.7 EXAMINATION

2.8 FACTORY TESTING

A. 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.

2.9 INSTALLATION

A. 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

A. 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.

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SECTION 26 36 23
AUTOMATIC TRANSFER SWITCHES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes transfer switches rated 600 V and less, including the following:

B. Automatic transfer switches

1. Related Sections include the following:

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.

1. Technical data on all major components of all transfer switches and other products described in this section. Data is required for the transfer switch mechanism, control system, cabinet, and protective devices specifically listed for use with each transfer switch. Include steady state and fault current ratings, weights, operating characteristics, and furnished specialties and accessories.
2. Single Line Diagram: Show connections between transfer switch, power sources and load

B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.

1. Dimensioned outline drawings of assembly, including elevations, sections, and details including minimal clearances, conductor entry provisions, gutter space, installed features and devices and material lists for each switch specified.
2. Internal electrical wiring and control drawings.
3. Interconnection wiring diagrams, showing recommended conduit runs and point-to-point terminal connections to generator set.
4. Installation and mounting instructions, including information for proper installation of equipment to meet seismic requirements.

C. Manufacturer and Supplier Qualification Data

1. The transfer switch manufacturer shall be certified to ISO 9001 International Quality Standard and shall have third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.
2. The manufacturer of this equipment shall have produced similar equipment for a minimum period of 10 years. When requested, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

D. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Features and operating sequences, both automatic and manual.
2. List of all factory settings of relays, timers and protective devices; provide setting and calibration instructions where applicable.

E. Warranty documents demonstrating compliance with the project's contract requirements.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: The equipment supplier shall maintain a service center capable of providing training, parts, maintenance and emergency repairs to equipment, including transfer switch generator sets and remote monitoring equipment (if applicable) at the site within a response period of less than (eight hours or appropriate time period designated for Project) from time of notification.

1. The transfer switch shall be serviced by technicians employed by, and specially trained and certified by, the generator set supplier and the supplier shall have a service organization that is factory-certified in both generator set and transfer switch service. The supplier shall maintain an inventory of critical replacement parts at the local service organization, and in service vehicles. The service organization shall be on call 24 hours per day, 365 days per year.
2. Submit names, experience level, training certifications, and locations for technicians that will be responsible for servicing equipment at this site.
3. The manufacturer shall maintain model and serial number records of each transfer switch provided for at least 20 years.

B. Source Limitations: All transfer switches are to be obtained through one source from a single manufacturer. The generator set manufacturer shall warrant transfer switches to provide a single source of responsibility for products provided.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked as suitable for use in emergency, legally required or optional standby use as appropriate for the connected load.

D. The automatic transfer switch installation and application shall conform to the requirements of the following codes and standards:

1. Transfer switches and enclosures shall be UL 1008 listed and labeled as suitable for use in emergency, legally required, and optional standby applications.
2. CSA 282, Emergency Electrical Power Supply for Buildings, and CSA C22.2, No. 14-M91 Industrial Control Equipment
3. NFPA 70, National Electrical Code. Equipment shall be suitable for use in systems in compliance with Articles 700, 701 and 702.
4. Comply with NEMA ICS 10-1993 AC Automatic Transfer Switches
5. IEEE 446 – Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
6. EN55011, Class B Radiated Emissions and Class B Conducted Emissions
7. IEC 1000-4-5 (EN 61000-4-5); AC Surge Immunity

8. IEC 1000-4-4 (EN 61000-4-4) Fast Transients Immunity
9. IEC 1000-4-2 (EN 61000-4-2) Electrostatic Discharge Immunity
10. IEC 1000-4-3 (EN 61000-4-3) Radiated Field Immunity
11. IEC 1000-4-6 Conducted Field Immunity
12. IEC 1000-4-11 Voltage Dip Immunity
13. IEEE 62.41, AC Voltage Surge Immunity
14. IEEE 62.45, AC Voltage Surge Testing

E. Comply with NFPA 99 – Essential Electrical Systems for Healthcare Facilities

F. Comply with NFPA 110 – Emergency and Standby Power Systems. The transfer switch shall meet all requirements for Level 1 systems, regardless of the actual circuit level.

G. The manufacturer shall warrant the material and workmanship of the transfer switch equipment for a minimum of one (1) year from registered commissioning and start-up, or eighteen (18) months from date of shipment.

H. The warranty shall be comprehensive. No deductibles shall be allowed for travel time, service hours, repair parts cost, and etc. during the minimum noted warranty period described above.

1.5 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service:

1. Notify Owner no fewer than 2 days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Owner's written permission.
3. Do not energize any new service or distribution equipment without notification and permission of the Owner

1.6 COORDINATION

A. Size and location of concrete bases and anchor bolt inserts shall be coordinated. Concrete, reinforcement and formwork must meet the requirements specified in Division 03. See section "INSTALLATION" for additional information on installation

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ASCO
2. Cummins Power Generation
3. Caterpillar
4. Kohler
5. Generac

B. Equipment specifications for this Project are based on automatic transfer switches manufactured by Cummins Power Generation. Switches manufactured by other manufacturers that meet the requirement of this specification are acceptable, if approved not less than two weeks before scheduled bid date. Proposals must include a line-by-line compliance statement based on this specification.

C. Transfer switches utilizing molded case circuit breakers do not meet the requirements of this specification and will not be accepted.

2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

A. Provide transfer switches in the number and ratings that are shown on the drawings.

B. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer.

C. Fault-Current Closing and Withstand Ratings: UL 1008 WCR ratings must be specifically listed as meeting the requirements for use with protective devices at installation locations, under specified fault conditions. Withstand and closing ratings shall be based on use of the same set of contacts for the withstand test and the closing test. Fault current rating shall be fully rated with breakers protecting switch. Coordinate with panelboard vendor.

D. Solid-State Controls: All settings should be accurate to +/- 2% or better over an operating temperature range of - 40 to + 60 degrees C (- 40 to + 140 degrees F).

E. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

F. Electrical Operation: Accomplished by a non-fused, momentarily energized solenoid or electric motor operator mechanism, mechanically and electrically interlocked in both directions (except that mechanical interlock is not required for closed transition switches). All switches shall include a center off delay (delayed transition) function to allow for motor loads to slow.

G. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Switches using molded-case switches or circuit breakers, or insulated case circuit breaker components are not acceptable.
2. Transfer switches shall be double-throw, electrically and mechanically interlocked, and mechanically held in the Source 1 and Source 2 positions.
3. Main switch contacts shall be high pressure silver alloy. Contact assemblies shall have arc chutes for positive arc extinguishing. Arc chutes shall have insulating covers to prevent inter-phase flashover.
4. Contacts shall be operated by a high-speed electrical mechanism that causes contacts to open or close within three electrical cycles from signal.
5. Transfer switch shall be provided with flame retardant transparent covers to allow viewing of switch contact operation but prevent direct contact with components that could be operating at line voltage levels.

6. The transfer switch shall include the mechanical and control provisions necessary to allow the device to be field-configured for operating speed. Transfer switch operation with motor loads shall be as is recommended in NEMA MG1.
    a. Phase angle monitoring/timing equipment is not an acceptable substitute for this functionality
7. Transfer switches designated on the drawings as “4-pole” shall have a full current-rated neutral bar with lugs.

H. Factory wiring: Transfer switch internal wiring shall be composed of pre-manufactured harnesses that are permanently marked for source and destination. Harnesses shall be connected to the control system by means of locking disconnect plug(s), to allow the control system to be easily disconnected and serviced without disconnecting power from the transfer switch mechanism

I. Terminals: Terminals shall be pressure type and appropriate for all field wiring. Control wiring shall be equipped with suitable lugs, for connection to terminal strips.

J. Enclosures: All enclosures shall be third-party certified for compliance to NEMA ICS 6 and UL 508, unless otherwise indicated:

1. The enclosure shall provide wire bend space in compliance to the latest version of NFPA70, regardless of the direction from which the conduit enters the enclosure.
2. Exterior cabinet doors shall provide complete protection for the system’s internal components. Doors must have permanently mounted key-type latches. Bolted covers or doors are not acceptable.
3. Transfer switches shall be provided in enclosures that are third party certified for their intended environment per NEMA requirements.

2.3 AUTOMATIC TRANSFER SWITCHES

A. Comply with requirements for Level 1 equipment according to NFPA 110.

B. Indicated current ratings:

1. Refer to the Project drawings for specifications on the sizes and types of transfer switch equipment, withstand and closing ratings, number of poles, voltage and ampere ratings, enclosure type, and accessories.
2. Main contacts shall be rated for 600 VAC minimum.
3. Transfer switches shall be rated to carry 100% of rated current continuously in the enclosure supplied, in ambient temperatures of -40 to +60 degrees C (-40 to +140 degrees F), relative humidity up to 95% (non-condensing), and altitudes up to 10,000 feet (3000 meters).

C. Relay Signal: Control shall include provisions for addition of a pre-transfer relay signal, adjustable from 0 to 60 seconds, to be provided if necessary for elevator operation, based on equipment provided for the project.

D. Transfer switches that are designated on the drawings as 4-pole shall be provided with a neutral bus and lugs. The neutral bus shall be sized to carry 100% of the current designated on the switch rating.

E. Automatic Transfer Switch Control Features

1. The transfer switch control system shall be configurable in the field for any operating voltage level up to 600 VAC. Voltage sensing shall be monitored based on the normal voltage at the site. Systems that utilize voltage monitoring based on standard voltage conditions that are not field configurable are not acceptable.
2. All transfer switch sensing shall be configurable from an operator panel or from a Windows XP or later PC-based service tool. Designs utilizing DIP switches or other electromechanical devices are not acceptable.
3. The transfer switch shall provide a relay contact signal prior to transfer or re-transfer. The time period before and after transfer shall be adjustable in a range of 0 to 60 seconds.
4. The control system shall be designed and prototype tested for operation in ambient temperatures from - 40 degrees C to + 60 degrees C (- 40 to +140 degrees F). It shall be designed and tested to comply with the requirements of the noted voltage and RFI/EMI standards.
5. The control shall have optically isolated logic inputs, high isolation transformers for AC inputs and relays on all outputs, to provide optimum protection from line voltage surges, RFI and EMI.
6. The transfer switch network monitoring equipment, when supplied, shall be provided with a battery-based auxiliary power supply to allow monitoring of the transfer switch when both AC power sources are non-operational.
7. Transfer switch shall be equipped with load shed option to drop load if the fire pump starts. See sequence of operation.

F. Transfer Switch Control Panel: The transfer switch shall have a microprocessor-based control with a sealed membrane panel incorporating pushbuttons for operator-controlled functions, and LED lamps for system status indicators. The panel shall also include an alphanumeric display for detailed system information. Panel display and indicating lamps shall include permanent labels.

1. The indicator panel LEDs shall display:
   a. Which source the load is connected to (Source 1 or Source 2)
   b. Which source or sources are available
   c. When switch is not set for automatic operation, the control is disabled
   d. When the switch is in test/exercise mode
2. The indicator shall have pushbuttons that allow the operator to activate the following functions:
   a. Activate pre-programmed test sequence
   b. Override programmed delays, and immediately go to the next operation
   c. Reset the control by clearing any faults
   d. Test all of the LEDs by lighting them simultaneously
3. The alphanumeric digital display shall be vacuum fluorescent-type, clearly visible in both bright sunlight and no-light conditions over an angle of 120 degrees, and shall display the following:
   a. AC voltage for all phases, normal and emergency
   b. Source status: connected or not connected.
4. The display panel shall be password-protected, and allow the operator to view and make adjustments:

a. Set nominal voltage and frequency for the transfer switch
b. Adjust voltage and frequency sensor operation set points
c. Set up time clock functions
d. Set up load sequence functions
e. Enable or disable control functions including program transition
f. View real-time clock data, operation log (hours connected, times transferred, failures) and service history

F. Control Functions: Functions managed by the control shall include:

1. Software adjustable time delays:
   a. Engine start (prevents nuisance genset starts in the event of momentary power fluctuation): 0 to 120 seconds (default 3 sec)
   b. Transfer normal to emergency (allows genset to stabilize before load is transferred): 0 to 120 seconds (default 3 sec)
   c. Re-transfer emergency to normal (allows utility to stabilize before load is transferred from genset): 0 to 30 minutes (default 3 sec)
   d. Engine cooldown: 0 to 30 minutes (default 10 min)
   e. Programmed Delayed Transition (Center Off Delay): 0 to 60 seconds (default 3 sec)
2. Undervoltage sensing: three-phase normal, three-phase emergency source.
3. Over-voltage sensing: three-phase normal, three-phase emergency source.
4. Over/under frequency sensing:
   a. Pickup: +/- 5 to +/-20% of nominal frequency (default 10%)
   b. Dropout: +/-1% beyond pickup (default 1%)
   c. Dropout time delay: 0.1 to 15.0 seconds (default 5 sec)
   d. Accurate to within +/- 0.05 Hz
5. Voltage imbalance sensing:
   a. Dropout: 2 to 10% (default 4%)
   b. Pickup: 90% of dropout
   c. Time delay: 2.0 to 20 seconds (default 5 sec)
6. Phase rotation sensing:
   a. Time delay: 100 msec
7. Loss of single-phase detection:
   a. Time delay: 100 msec

G. Control features shall include:

1. Programmable genset exerciser: A field-programmable control shall periodically start and run the generator with or without transferring the load for a preset time period, then re-transfer and shut down the generator after a preset cool-down period.
2. In event of a loss of power to the control, all control settings, real-time clock setting and the engine start-time delay setting will be retained.
3. The system continuously logs information including the number of hours each source has been connected to the load, the number of times transferred, and the total number of times each source has failed. An event recorder stores information, including time and date-stamp, for up to 50 events.

4. Re-Transfer Inhibit Switch: Inhibits automatic re-transfer control so automatic transfer switch will remain connected to emergency power source as long as it is available regardless of condition of normal source.
5. Transfer Inhibit Switch: Inhibits automatic transfer control so automatic transfer switch will remain connected to normal power source regardless of condition of emergency source.

H. Control Interface

1. Provide one set Form C auxiliary contacts on both sides, operated by transfer switch position, rated 10 amps 250 VAC.

I. Engine Starting Contacts

1. One isolated and normally closed pair of contacts rated 10A at 32 VDC minimum.

2.4 REMOTE ANNUNCIATOR SYSTEM

A. Functional Description: Remote annunciator panel shall annunciate conditions for indicated transfer switches. Annunciation shall include the following:

1. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
2. Switch position.
3. Switch in test mode.
4. Failure of communication link.

B. Annunciator Panel: LED-lamp type with audible signal and silencing switch.

C. Indicating Lights: Grouped for each transfer switch monitored.

D. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.

E. Switch in test mode.

F. Lamp Test: Push-to-test or lamp-test switch on front panel.

G. Malfunction of annunciator or communication link shall not affect functions of automatic transfer switch. In the event of failure of communication link, automatic transfer switch automatically reverts to stand-alone, self-contained operation.

H. Automatic transfer-switch sensing, controlling, or operating function shall not depend on remote panel for proper operation. The remote annunciation system shall not prevent transfer to the alternate source when the primary power source fails, nor prevent return to the primary source if the alternate source fails.

PART 3 EXECUTION

3.1 INSTALLATION

A. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

B. Floor-Mounting Switch: Anchor to floor by bolting.

1. Floor-mounted transfer switches (except drawout switches supported by wheeled carriages, which must be rolled out at floor level) shall be mounted on concrete bases complying with the following requirements:
   a. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 4 inches (100 mm) in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to Division 26 Section "Hangers and Supports for Electrical Systems."

C. Annunciator Panel Mounting: Flush in wall, unless otherwise indicated.

D. Identify components according to Division 26 Section "Identification for Electrical Systems."

E. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

B. Field control connections shall be made on a common terminal block that is clearly and permanently labeled.

C. Transfer switch shall be provided with AL/CU mechanical lugs sized to accept the full output rating of the switch. Lugs shall be suitable for the number and size of conductors shown on the drawings.

D. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 SOURCE QUALITY CONTROL

A. Prior to shipping, factory shall test and inspect components, assembled switches, and associated equipment to ensure proper operation.

B. Factory shall check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements.

C. Factory shall perform dielectric strength test complying with NEMA ICS 1.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: The supplier of the transfer switch(es) and associated equipment shall inspect, test, and adjust components, assemblies, and equipment installations, including connections, and report results in writing.

B. Manufacturer’s representative shall perform tests and inspections and prepare test reports.

C. After installing equipment and after electrical circuitry has been energized, installer shall test for compliance with requirements.

1. Perform recommended installation tests as recommended in manufacturer’s installation and service manuals.
2. After energizing circuits, demonstrate interlocking sequence and operational function for each switch.
   b. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
   c. Verify time-delay settings.
   d. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

3.5 DEMONSTRATION

A. After generator set installation, the generator and transfer switch supplier shall conduct a complete operation, basic maintenance, and emergency service seminar covering generator set and transfer switch equipment, for up to 10 people employed by the Owner.

1. The seminar shall include instruction on operation of the transfer equipment, normal testing and exercise, adjustments to the control system, and emergency operation procedures.
2. The class duration shall be at least 8 hours in length, and include practical operation with the installed equipment.

- END OF SECTION -

SECTION 26 41 00
LIGHTNING PROTECTION

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:

B. Air terminals and interconnecting conductors.

C. Grounding and bonding for lightning protection.

1.2 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 26 05 00 - Electrical General Requirements.

C. Section 26 05 19 - 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 26 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 -

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SECTION 26 51 13
INTERIOR LUMINAIRES

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. Interior luminaires and accessories.
2. Emergency lighting units.
3. Exit signs.
4. Ballasts.
5. Fluorescent lamp emergency power supply.
6. Lamps.
7. Luminaire accessories.

1.2 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 260500- Electrical General Requirements.

1.3 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.

1.4 SUBMITTALS FOR REVIEW

A. Section 260500 - 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.

1.5 SUBMITTALS FOR CLOSEOUT

A. Section 260500 - Electrical General Requirements

B. Submit manufacturer's operation and maintenance instructions for each product.

1.6 QUALIFICATIONS

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

1.7 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.

1.8 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 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

2.1 LUMINAIRES

A. Furnish Products as scheduled. Refer to Section 260500 for substitutions and product options.

B. Lighting Fixtures: Shall be as shown in the Lighting Fixture Schedule on the Drawings.

2.2 LAMPS

A. LAMPS: shall be provided for all lighting fixtures in accordance with the lighting fixtures schedule on the drawings. Unless noted otherwise fluorescent lamps shall be 3000°K "energy saving type". 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

B. Lamp Types: As specified for luminaire. Refer to Section 260500 for substitutions and product options.

2.3 NOT USED

2.4 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.

2.5 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.

2.6 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.

2.7 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.

2.8 NOT USED

2.9 NOT USED

2.10 NOT USED

2.11 LUMINAIRES FOR HAZARDOUS LOCATIONS

A. 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

A. NEMA SSL 1, UL 8750. LED drivers must be electronic, UL Class 1, constant-current type and comply with the following requirements:

1. Output power (watts)and luminous flux (lumens) as shown in luminaire schedule for each luminaire type to meet minimum luminaire efficacy (LE) value provided.
2. Factor (PF) greater than or equal to 0.9 over the full dimming range when provided.
3. Current draw Total Harmonic Distortion (THD) of less than 20 percent.
4. Class A sound rating.
5. Operable at input voltage of 120-277 volts at 60 hertz.
6. Minimum 5-year manufacturer's warranty.
7. RoHS compliant.
8. Integral thermal protection that reduces or eliminates the output power if case temperature exceeds a value detrimental to the driver.
9. UL listed for dry or damp locations typical of interior installations.
10. 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

A. NEMA ANSLG C78.377, NEMA SSL 3. Provide type and wattage as indicated in luminaire schedule on project plans.

B. LED Light Sources

1. Correlated Color Temperature (CCT) of 3000 or 4000 degrees K as indicated.
2. Minimum Color Rendering Index (CRI) R9 value of 80.
3. High power, white light output utilizing phosphor conversion (PC) process or mixed system of colored LEDs, typically red, green and blue (RGB).
4. RoHS compliant.
5. 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:

1. 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.
2. Shall utilize 40Khz +/- .006% ultrasonic frequency.
3. Shall provide an adjustable time delay of 15 seconds to 15 minutes and an LED indicator for both technologies.
4. Shall provide adjustable sensitivities, and shall be capable of installing two units per power pack.
5. Shall be UL listed with a 5 year warranty.

PART 3 EXECUTION

3.1 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.

3.2 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.

3.3 ADJUSTING

A. Section 260500 Contract Closeout

3.4 CLEANING

A. Section 260500 - 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.

3.5 DEMONSTRATION AND INSTRUCTIONS

A. Section 260500 - Contract Closeout - Starting of Systems: Demonstrating installed work.

B. Demonstrate luminaire operation for 12 hours.

3.6 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 26 56 00
AREA LIGHTING

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: Exterior area, façade and landscape lighting.

1.2 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 26 05 00- Electrical General Requirements.

1.3 REFERENCES

(NEW)

1.4 SUBMITTALS FOR REVIEW

A. Section 26 05 00 - 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.

1.5 SUBMITTALS FOR CLOSEOUT

A. Section 260500 - Electrical General Requirements

B. Submit manufacturer's operation and maintenance instructions for each product.

1.6 QUALIFICATIONS

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

1.7 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.

1.8 EXTRA PRODUCTS

A. Section 26 05 00 - 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.

1.9 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.

1. AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)
   a. ASHRAE 189.1 (2014) Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings
   b. ASHRAE 90.1 - IP (2013) Energy Standard for Buildings Except Low-Rise Residential Buildings
   c. ASHRAE 90.1 - SI (2013) Energy Standard for Buildings Except Low-Rise Residential Buildings
2. ASTM INTERNATIONAL (ASTM)
   a. ASTM A123/A123M (2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
   b. ASTM A153/A153M (2016) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
   c. ASTM B108/B108M (2015) Standard Specification for Aluminum-Alloy Permanent Mold Castings
   d. ASTM B117 (2016) Standard Practice for Operating Salt Spray (Fog) Apparatus
   e. ASTM C1089 (2013) Standard Specification for Spun Cast Prestressed Concrete Poles
   f. ASTM G154 (2016) Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials
3. CALIFORNIA ENERGY COMMISSION (CEC)
   a. CEC Title 24 (2008; Effective Jan 2010) California's Energy Efficiency Standards for Residential and Nonresidential Buildings
4. ILLUMINATING ENGINEERING SOCIETY (IES)
   a. IES HB-10 (2011; Errata 2015) IES Lighting Handbook
   b. IES LM-79 (2008) Electrical and Photometric Measurements of Solid-State Lighting Products
   c. IES LM-80 (2015) Measuring Lumen Maintenance of LED Light Sources
   d. IES RP-16 (2010; Addendum A 2008; Addenda B 2009; Addendum C 2016) Nomenclature and Definitions for Illuminating Engineering
   e. IES RP-8 (2014) Roadway Lighting
   f. IES TM-15 (2011) Luminaire Classification System for Outdoor Luminaires

g. IES TM-21 (2011; Addendum B 2015) Projecting Long Term Lumen Maintenance of LED Light Sources

5. AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI) / NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)
   a. ANSI ANSLG C78.41 (2006) For Electric Lamps--Guidelines for Low-Pressure Sodium Lamps
   b. ANSI ANSLG C78.42 (2009; R 2016) For Electric Lamps: High-Pressure Sodium Lamps
   c. ANSI C136.13 (2004; R 2009) American National Standard for Roadway Lighting Equipment, Metal Brackets for Wood Poles
   d. ANSI C136.21 (2014) American National Standard for Roadway and Area Lighting Equipment - Vertical Tenons Used with Post-Top-Mounted Luminaires
   e. ANSI C136.3 (2014) American National Standard for Roadway and Area Lighting Equipment Luminaire Attachments
   f. ANSI C78.1381 (1998) American National Standard for Electric Lamps - 250-Watt, 70 Watt, M85 Metal-Halide Lamps
   g. ANSI C82.4 (2002) American National Standard for Ballasts for High-Intensity-Discharge and Low-Pressure Sodium (LPS) Lamps (Multiple-Supply Type)
   h. ANSI/ANSLG C78.43 (2013) American National Standard for Electric Lamps - Single-Ended Metal-Halide Lamps
   i. ANSI/NEMA C78.LL 1256 (2003; R 2015) Procedures for Fluorescent Lamp Sample Preparation and the Toxicity Characteristic Leaching Procedure (TCLP)
   j. NEMA 250 (2014) Enclosures for Electrical Equipment (1000 Volts Maximum)
   k. NEMA ANSLG C78.377 (2015) American National Standard for Electric Lamps—Specifications for the Chromaticity of Solid State Lighting Products
   l. NEMA ANSLG C78.380 (2007) Electric Lamps - High Intensity Discharge Lamps, Method of Designation
   m. NEMA ANSLG C78.44 (2008) For Electric Lamps - Double-Ended Metal Halide Lamps
   n. NEMA ANSLG C82.11 (2011) Lamp Ballasts - High-Frequency Fluorescent Lamp Ballasts
   o. NEMA ANSLG C82.14 (2006) Lamp Ballasts Low-Frequency Square Wave Electronic Ballasts -- for Metal Halide Lamps
   p. 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
   q. NEMA C136.20 (2012) American National Standard for Roadway and Area Lighting Equipment - Fiber Reinforced Composite (FRC) Lighting Poles
   r. NEMA C136.31 (2010) American National for Roadway and Area Lighting Equipment - Luminaire Vibration
   s. NEMA C78.LL 3 (2003; R 2015) Electric Lamps - Procedures for High Intensity Discharge Lamp Sample Preparation and the Toxicity Characteristic Leaching Procedure
   t. NEMA C82.77 (2002) Harmonic Emission Limits - Related Power Quality

Requirements for Lighting Equipment

u. NEMA ICS 2 (2000; R 2005; Errata 2008) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 VNEMA ICS 6 (1993; R 2011) Industrial Control and Systems: Enclosures

v. NEMA IEC 60529 (2004) Degrees of Protection Provided by Enclosures (IP Code)

w. NEMA WD 7 (2011; R 2016) Occupancy Motion Sensors Standard

6. NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)
   a. NFPA 70 (2017) National Electrical Code
7. UNDERWRITERS LABORATORIES (UL)
   a. UL 1029 (1994; Reprint Dec 2013) High-Intensity-Discharge Lamp Ballasts
   b. UL 1310 (2011; Reprint Dec 2014) UL Standard for Safety Class 2 Power Units
   c. UL 1598 (2008; Reprint Oct 2012) Luminaires
   d. UL 773 (1995; Reprint Jul 2015) Standard for Plug-In, Locking Type Photocontrols for Use with Area Lighting
   e. UL 773A (2016) Standard for Nonindustrial Photoelectric Switches for Lighting Control
   f. UL 8750 (2015; Reprint Nov 2016) UL Standard for Safety Light Emitting Diode (LED) Equipment for Use in Lighting Products
   g. UL 916 (2007; Reprint Aug 2014) Standard for Energy Management Equipment
   h. UL 935 (2001; Reprint Aug 2014) Standard for Fluorescent-Lamp Ballasts

1.10 WARRANTY

A. 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

A. Provide Luminaire Useful Life Certificate.

B. 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.

C. 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.

3. Warranty period must begin on date of beneficial occupancy. Contractor shall provide the Contracting Officer signed warranty certificates prior to final payment.

1.12 ELECTRONIC BALLAST WARRANTY

A. Furnish the electronic ballasts manufacturer's warranty. The warranty period shall not be less than five (5) years from the date of manufacture. Ballast 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 shall be exchanged by the manufacturer and promptly shipped to the using Government facility.

B. The replacement ballast shall be identical to, or an improvement upon, the original design of the malfunctioning ballast.

PART 2 PRODUCT

2.1 LUMINAIRES

A. Furnish Products as scheduled. Refer to Section 260500 for substitutions and product options.

B. Lighting Fixtures: Shall be as shown in the Lighting Fixture Schedule on the Drawings.

2.2 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

Application	Luminaire Efficacy in Lumens per Watt
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.

2.3 NOT USED

2.4 LED LIGHT SOURCES

A. Correlated Color Temperature (CCT) shall be in accordance with NEMA ANSLG C78.377:

1. 4000K or as per Color temperature As per fixture schedule.

B. Color Rendering Index (CRI) shall be:

1. Greater than or equal to 70 or as per fixture schedule

C. Color Consistency:

1. Manufacturer shall utilize a maximum 4-step MacAdam ellipse binning tolerance for color consistency of LEDs used in luminaires.

2.5 LUMINAIRE DRIVERS

A. LED POWER SUPPLY UNITS (DRIVERS)

1. UL 1310. LED Power Supply Units (Drivers) shall meet the following requirements:
   a. Minimum efficiency shall be 85 percent.
   b. Drive current to each individual LED shall not exceed 600 mA, plus or minus 10 percent.
   c. 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].
   d. Shall be designed to operate on the voltage system to which they are connected, typically ranging from 120 V to 480 V nominal.
   e. Operating frequency shall be: 50 or 60 Hz.
   f. Power Factor (PF) shall be greater than or equal to 0.90.
   g. Total Harmonic Distortion (THD) current shall be less than or equal to 20 percent.
   h. Shall meet requirements of 47 CFR 15, Class B.
   i. Shall be RoHS-compliant.
   j. Shall be mounted integral to luminaire. Remote mounting of power supply is not allowed.
   k. 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.
   l. Shall be dimmable, and compatible with a standard dimming control circuit of 0 - 10V or other approved dimming system.
   m. Shall be equipped with over-temperature protection circuit that turns light source off until normal operating temperature is achieved.

2.6 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

3.1 INSTALLATION

A. Install luminaires as detailed on the drawings or to poles as directed.

3.2 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.

3.3 ADJUSTING

A. Section 26 05 00 Contract Closeout

3.4 CLEANING

A. Section 26 05 00 - 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.

3.5 DEMONSTRATION AND INSTRUCTIONS

A. Section 26 05 00 - Contract Closeout - Starting of Systems: Demonstrating installed work.

B. Demonstrate luminaire operation for 12 hours.

3.6 PROTECTION OF FINISHED WORK

A. Re-lamp or repair luminaires that have failed at substantial completion.

3.7 FIELD APPLIED PAINTING

A. 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.

3.8 FIELD QUALITY CONTROL

A. 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 -

SECTION 26 80 10
HVAC SYSTEMS CONTROL

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:

B. 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 26) and his controls sub-contractor. The plant PLC system shall control HVAC systems.
2. All electrical work shall be in accordance with Division 26.
3. Division 26 shall provide all power to and throughout the building, to include motor control centers, breaker panels, and all other systems designated to Division 26, and specified herein. Division 26 shall install all conduit systems.
4. Division 26 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 26 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 26.
7. All wiring shall terminate at labeled terminal strips.

1.2 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:

1. Section 26 05 00 - Electrical General Requirements.
2. Section 26 05 19 – Conductors and Cables.

1.3 SUBMITTALS

A. Reference Section 26 05 00

B. 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 -