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TITLE PAGE

CONSTRUCTION OF

Provo City Water Reclamation Facility
Phase 1, Electrical Re-feed Packages A-E

BID NO. PROVOEN202529386

CONTRACT DOCUMENTS

City of Provo Water Resources
Water Reclamation Facility
Phase 1, Electrical Refeed Packages A-E
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Bids will be received and deposited at the office of the Provo City Public Works Building, located at the above address, until 2:00 PM on Wednesday, March 20, 2025.

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T A B L E O F C O N T E N T S

Provo City Water Reclamation Facility
Phase 1, Electrical Refeed Packages A-E
Bid No. PROVOEN202529386

SECTION 26 00 00

GENERAL ELECTRICAL PROVISIONS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope of Work:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified, and required to complete the electrical Work, including power distribution; grounding; lighting; miscellaneous power; building special systems such as security, closed circuit television, fire alarm, and lightning protection; controls; instrumentation; supervisory control and data acquisition, equipment provided under other specification sections; etc.
   2. Provide mobilization, project coordination, demolition, and maintenance of operation services as required for the work in accordance with the specifications and the drawings.
   3. Equipment shall be rated and labeled by the manufacturer for the environmental conditions in which it is installed including the power disconnects, control stations, and wiring systems.
   4. Provide a preliminary short circuit and coordination analysis prior to the initial submittal of the electrical distribution equipment submittal to confirm the equipment being provided new and the existing equipment are appropriately rated for the short circuit duty available and to ensure that the protective devices being provided properly coordinate among themselves and with the existing installed equipment.
   5. Provide a final short circuit, protective devices coordination and arc flash analysis to be used for setting the protective devices and for providing the appropriate safety arc flash labeling on all equipment, existing and new after all submittals are approved. In addition, the final analysis report will be used by the OWNER as a benchmark for setting and testing protective devices in the future.
   6. Provide conduit, wire and field connections for all motors, motor controllers, control devices, control panels and electrical equipment furnished under other Divisions.
   7. Provide conduit, wiring and terminations for all field-mounted instruments furnished under other Divisions, including process instrumentation primary elements, transmitters, local indicators and control panels. Provide disconnect switches and lightning and surge protection equipment wiring at process instrumentation transmitters. Install vendor furnished cables specified under other Divisions.
   8. Provide complete network cables and specialty cable systems. Install the network cables and other specialty cable systems furnished under other Divisions in accordance with the system manufacturers' installation instructions. Coordinate the raceway layout, prior to rough-in, with the computer system supplier and the cable manufacturer to ensure raceway compatibility with the systems and materials being furnished. Where redundant cables are furnished, install cables in separate raceways. Maintain an 8-foot (minimum) separation between raceways with no single point of failure where practical and reasonable. Practical and reasonable shall be defined jointly by the Electrical Contractor, Prime Contractor, and Electrical Engineer.
   9. Provide a complete Fiber Optic Network System. Install the Fiber Optic Cables and other specialty cable systems furnished under other specification divisions in accordance with the system manufacturers' installation instructions. Review the raceway layout, prior to installation, with the OWNER IT staff, fire alarm and

computer equipment system suppliers, and the cable manufacturers to ensure raceway compatibility with the systems and materials being furnished.

10. Installation of variable frequency drives furnished under other Divisions, including conduit, wiring and terminations, and associated equipment such as reactors, harmonic filters, transformers and power factor correction capacitors.
11. Provide power wiring for all heating, ventilating, and air conditioning equipment furnished under other related Divisions. Provide 120 V wiring for unit heater motors and thermostats and exhaust fan/light combination controls where required. Refer to HVAC Drawings for the locations of 120 V unit heater thermostats and provide a 3/4-inch C, 2 No. 12 and 1 No. 12 GRD between each heater and its respective control thermostat.
12. Provide precast manholes, handholes and light pole bases with appropriately traffic-rated frames and covers.
13. Provide all necessary electrical work and materials necessary to make laboratory equipment operative (e.g., still, water-baths, fume hood, etc.).
14. Provide modifications to existing control systems as required to provide the control functions or inputs as shown on the Drawings. Verify all existing wiring and connections and provide installation of new auxiliary motor starter contacts, relays, switches, etc. Trace the circuits in the field and develop the wiring diagrams necessary for completion of the work. Document all changes made to the wiring diagrams and return a complete marked-up set of Record Drawings, with point-to-point terminal numbers, to the OWNER after the work is complete.
15. Coordinate with the Telecommunications Service Provider to provide High Speed Internet service from the service provider.
16. Perform testing of the electrical equipment in accordance with the requirements of the other Division 26 specifications. If the testing results are not within acceptable limits repair or replace all defective work and equipment at no additional cost to the OWNER. Make adjustments to the systems furnished under Division 26, Electrical in accordance with the equipment manufacturers requirements/recommendations.
17. Set the electrical protective devices in accordance with NETA standards and in accordance with the protective coordination study.

B. Demolition
    1. Provide electrical demolition work associated with the removal of equipment from the existing facilities. The work shall include disconnecting and removing electrical disconnect switches, electrical wiring and conduit to equipment. Make equipment scheduled for removal free of electrical shock hazard.
    2. Survey the existing electrical systems and equipment identified for removal with representatives from the other trades prior to performing any demolition work. Identify all conduit and equipment to be removed with tags or paint. Where a piece of equipment is to be removed all associated ancillary components (e.g., solenoid valves, pressure switches, etc.) and associated wiring and conduit shall also be removed.
    3. Equipment scheduled to be turned over to the OWNER shall be carefully disconnected, removed and delivered to the OWNER at a location within the existing site. Provide labor, hoisting, and transportation of the equipment. All other miscellaneous electrical materials, devices, etc., associated with the equipment being turned over shall be demolished and removed from the site. The following equipment shall be turned over to the OWNER:
        a. Control panels
        b. Switchgear
        c. Switchboards

d. Panelboards
e. Transformers

4. Provide electrical relocation work associated with the relocation of equipment for the existing and new facilities, including disconnecting all existing wiring and conduits and providing new wiring and conduit to the relocated equipment. Make equipment scheduled for relocation free of electrical shock hazard in accordance with OSHA and local plant electrical safety requirements.
5. Unless otherwise specifically noted, remove unused exposed conduit and support systems back to point of concealment including abandoned conduit above accessible ceiling finishes. Remove unused wiring back to source (or nearest point of usage).
6. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned or being removed. Provide blank covers for abandoned outlets which are not removed.
7. Disconnect and remove abandoned panelboards, disconnect switches, control stations, distribution equipment, etc.
8. Disconnect and remove abandoned luminaires. Remove brackets, stems, hangers and other accessories.
9. Repair adjacent construction and finishes damaged during demolition and extension work.
10. Where electrical systems pass through the demolition areas to serve other portions of the premises, they shall remain or be suitably relocated, and the system restored to normal operation.
11. Coordinate electrical power outages to the electrical systems and equipment with the OWNER. Where duration of proposed outage cannot be allowed by the OWNER (4 hour duration maximum), phase the retrofit work to allow the system or equipment to be re-connected to the electrical power system within the time frame allowed by the OWNER or provide temporary power connections as required to maintain service to the systems or equipment. The temporary power can be from a generator or another part of the facility not affected by the outage provided there is sufficient spare capacity.
12. Continuous service is required on all circuits and outlets affected by these changes, except where the OWNER will permit an outage for a specific time. Obtain OWNER's consent before removing any circuit from continuous service.
13. The electrical and process equipment to be removed or relocated under this contract has been identified on the Drawings. The removal and or relocation of existing conduit, wire and equipment have not been detailed on the Drawings. Survey the affected equipment and building areas before submitting bid proposal.
14. Trace out existing wiring that is to be relocated or removed and perform the relocation or removal work as required for a complete operating and safe system.
15. Remove exposed conduits, wireways, outlet boxes, pull boxes and hangers made obsolete by the alterations, unless specifically designated to remain. Patch surfaces and provide blank covers for abandoned outlets which are removed.
16. All equipment, materials, controls, motor starters, branch and feeder breakers, panelboards, transformers, wiring, raceways, etc., furnished and installed to temporarily keep circuits energized shall be removed when the permanent installation is fully operational.
17. Disposition of removed materials and equipment
    a. It is intended that material and equipment indicated to be removed and disposed of by the CONTRACTOR shall, upon removal, become the CONTRACTOR's property and shall be disposed of off the site by the CONTRACTOR, unless otherwise directed by the OWNER. A receipt showing acceptable disposal of any legally regulated materials or equipment shall be given to the OWNER.

b. PCBs, mercury and PCB/mercury contaminated equipment shall be removed, packaged, shipped and disposed of in accordance with all State and Federal regulations. Obtain the services of a firm licensed and regularly engaged in the removal of PCBs and PCB contaminated equipment. The firm shall be licensed in the State or States in which the contaminated material is handled, shipped and disposed. Pay all fees associated with the removal of the contaminated material and equipment and provide documentation showing acceptable disposal.

C. Coordination:
1. Coordinate the electrical service requirements with Provo Power Utility Company and provide the electrical service from the power company at the locations indicated.
2. Review installation procedures, drawings and schedules under other Sections and coordinate with other trades the installation of electrical items that must be installed with or within formwork, walls, partitions, ceilings and panels.
3. Coordinate with other contractors and provide the installation of all conduits, inserts, and other items to be embedded in concrete, or built into walls, partitions, ceilings, or panels constructed by other contractors. Provide detailed sketches of the location of conduits and other built-in items prior to rough-in. Install conduits and other built-in items in such a manner and within such time periods as will not unnecessarily delay the work of other contractors.
4. Each bidder or their authorized representatives shall, before preparing their proposal, visit all areas of the existing buildings and structures in which work under this bid is to be performed and inspect carefully the present installation. The submission of the proposal by this bidder shall be considered evidence that their representative has visited the buildings and structures and noted the locations and conditions under which the work will be performed and that he/she takes full responsibility for a complete knowledge of all factors governing his/her work that can reasonably be seen. Reasonable shall be defined jointly by the Electrical Contractor, Prime Contractor, and Electrical Engineer.
5. Review the electrical underground system and the civil yard piping. Install the electrical underground system in a manner that avoids conflicts with manholes, catch basins, etc. provided under other Divisions of the specifications.
6. Provide rubber floor mats for all electrical equipment, including switchgear, switchboards, and motor control centers.
7. Excavation, bedding material, forms, concrete and backfill for underground raceways; forms and concrete for electrical equipment furnished under Division 26, Electrical. The work shall be in accordance with Divisions 03, Concrete, and Division 31, Earthwork.

D. Contract Documents:
1. Interpretation of Drawings:
a. Dimensions shown on the Drawings that are related to equipment are based on the equipment of one manufacturer. Confirm the dimensions of the equipment furnished to the space allocated for that equipment.
b. The Drawings show the principal elements of the electrical Work. They are not intended as detailed working drawings for the electrical Work, but as a complement to the Specifications to clarify the principal features of the electrical systems.
c. It is the intent of the Drawings and Specifications that all equipment and devices, furnished and installed under this Contract, be properly connected and interconnected with other equipment and devices so as to render the installations complete for successful operation, regardless of whether all the connections and

interconnections are specifically mentioned in the Specifications or shown on the Drawings.

d. Conduit and wiring is indicated schematically on the drawings to show the desired functionality. Refer to the One-Line diagrams, Control Block Diagrams, Panelboard schedules, Schematic Diagrams, Loop Wiring diagrams, Network Diagrams, and Process and Instrumentation Drawings for wiring requirements.
e. Wiring details are not shown on the plan drawings. CONTRACTOR to determine the optimum field routing and provide all fittings and accessories necessary for a complete system.
f. Schematic Diagrams:
    1) Schematic diagrams are provided for CONTRACTOR'S guidance in fulfilling the operational intent of the Contract Documents.
    2) Responsibility belongs to CONTRACTOR to meet all safety and electrical codes, and to provide all equipment, appurtenances and specialty items required to provide for complete and operable systems. Devices intended for safety interlocks to protect personnel shall be UL safety rated. Devices intended for safety interlocks to protect equipment shall be fail-safe.
    3) Review of control schemes submitted by CONTRACTOR does not relieve CONTRACTOR of his contractual responsibility to provide complete and successfully operating systems.
g. Underground duct bank raceways may be a minimum of 2-inch regardless of the conduit sizes indicated on the wiring drawings.
h. It is the intent of the Contract Documents that similar products are provided by the same manufacturer for uniformity on the Project.

2. Priority of the contract documents
    a. If, during the performance of the work, the CONTRACTOR finds a conflict, error or discrepancy between or among one or more of the Sections or between or among one or more Sections and the Drawings, furnish the higher performance requirements. The higher performance requirement shall be considered the equipment, material, device or installation method which represents the most stringent option, the highest quality or the largest quantity.
    b. In all cases, figured dimensions shall govern over scaled dimensions, but work not dimensioned shall be as directed by the ENGINEER and work not particularly shown, identified, sized, or located shall be the same as similar work that is shown or specified.
    c. Detailed Drawings shall govern over general drawings, larger scale Drawings take precedence over smaller scale Drawings, Change Order Drawings shall govern over Contract Drawings and Contract Drawings shall govern over shop drawings.
    d. If the issue of priority is due to a conflict or discrepancy between the provisions of the Contract Documents and any referenced standard, or code of any technical society, organization or association, the provisions of the Contract Documents will take precedence if they are more stringent or presumptively cause a higher level of performance. If there is any conflict or discrepancy between standard specifications, or codes of any technical society, organization or association, or between Laws and Regulations, the higher performance requirement shall be binding on the CONTRACTOR, unless otherwise directed by the ENGINEER.
    e. In accordance with the intent of the Contract Documents, the CONTRACTOR accepts the fact that compliance with the priority order specified shall not justify an increase in Contract Price or an extension in Contract Time nor limit in any way, the CONTRACTOR's responsibility to comply with all Laws and Regulations at all times

E. Temporary Power and Lighting:
   1. Coordinate temporary power with Provo Power Utility Company and OWNER. If utilizing existing facility power, upon approval, provide updated panel schedules and/or load summaries to the ENGINEER and OWNER identifying the recommended power sources and circuits for temporary services. ENGINEER and OWNER must provide approval prior to connecting to the services.

F. Power Utility Service:
   1. The power company serving this project is Provo Power. Service will be obtained at 12,470 V, 3 Ph, 4 Wire, 60 Hz from a service riser furnished and installed by Provo Power.
   2. The power company will be responsible for the following work:
      a. Furnishing and installing the primary overhead conductors and pole line.
      b. Furnishing and installing the first riser pole on the property, primary cutouts, lightning arresters and grounding.
      c. Furnishing and installing primary cables.
      d. Furnishing and installing the transformer grounding.
      e. Furnishing and installing transformer.
      f. Termination of underground primary cables at riser pole.
      g. Termination of underground primary cables at the transformer.
      h. Furnishing metering current transformers (C.T.'s), meter and meter wiring.
      i. Furnishing and installing secondary conduits and cables.
      j. Furnishing meter base and enclosure.
   3. The CONTRACTOR shall be responsible for the following work:
      a. Obtain an estimate from the power company for the work described above and include the cost of the power company work in the Bid Price.
      b. Make all arrangements with the power company for obtaining electrical service, including all utility design services, construction, inspections, and fees; pay all power company charges; and furnish all labor and material required for the electrical service.
      c. Furnishing and installing the primary conduits.
      d. Furnishing and installing the transformer pad.
      e. Furnishing secondary conduits and cables.
      f. Furnishing and installing a power company approved metering current transformer enclosure.
      g. Furnishing and installing an empty conduit with pull-tape from the metering C.T. enclosure to the meter enclosure. Conduit size and type shall be approved by the power company.
   4. Submit shop drawings for the following items to the power company for approval:
      a. Service Entrance Section.
      b. Manholes and duct bank plans.
      c. Concrete equipment pads for utility equipment.
      d. Meter base.
      e. Primary conduit.
      f. Metering instrument and installation.

1.2 QUALITY ASSURANCE

A. Requirements of Regulatory Agencies:
   1. Permits: Obtain all permits and pay fees required to commence Work and, upon completion of the Work, obtain and deliver to the ENGINEER a Certificate of Inspection and Approval from the authority having jurisdiction.

2. Codes: Material and equipment shall be installed in accordance with the current standards and recommendations of the National Electrical Code, the National Electrical Safety Code and with local codes which apply. Where discrepancies arise between codes, the most restrictive regulation shall apply.
3. Tests by Independent Regulatory Agencies: Electrical material and equipment shall be new and shall bear the label of the Underwriters' Laboratories, Inc., or other nationally-recognized, independent testing laboratory, wherever standards have been established and label service regularly applies.
4. Utilities:
   a. Provo Power Company: Work in connection with the electric service and utility metering shall be done in strict conformance with the requirements of Provo Power Company.
   b. Telephone Company: Work in connection with the telephone lines for the telephone service shall be done in strict conformance with the requirements of the Telephone Company. Telephone system within the Plant is a private system and shall be coordinated with the City of Provo, Information Technology Department.
   c. City of Provo, Information Technology Department.

B. Reference Standards: Electrical material and equipment shall conform in all respects to the latest approved standards of the following:
1. National Electrical Manufacturers Association (NEMA).
2. The American National Standards Institute (ANSI).
3. The Institute of Electrical and Electronic Engineers (IEEE).
4. Insulated Cable Engineers Association (ICEA).
5. National Electrical Code (NEC) current adoption.
6. National Electrical Safety Code (NESC).
7. American Society for Testing and Materials International (ASTM).
8. The Instrumentation, Systems and Automation Society (ISA).
9. National Fire Protection Agency (NFPA).
10. Underwriter's Laboratories, Inc. (UL).
11. Occupational Safety and Health Administration (OSHA).
12. Factory Mutual (FM)
13. International Electrical Testing Association (NETA)
14. State of Utah Building Code
15. International Building Code (IBC)
16. City of Provo Building Code
17. International Fire Code (IFC)
18. International Energy Conservation Code (IECC)
19. The Building Officials and Code Administrators National Building Code (BOCA)
20. ASTM International
21. Institute of Electrical and Electronics Engineers (IEEE)
22. Joint Industrial Council (JIC)

C. Warranty: Warrant all equipment furnished under Division 26, Electrical, in accordance with Division 01, General Requirements and individual Division 26, Electrical equipment sections. Minimum warranty period shall be one year from date of substantial completion for the project, or manufacture's standard warranty, whichever is longer.

D. Wiring Coordinator:

1. Retain the services of a Wiring Coordinator who shall prepare complete point-to-point interconnection wiring termination sheets. The sheets shall identify all external interconnecting wiring associated with all new and modified existing equipment.
   a. Qualifications: Coordinator shall have experience in the development of the point-to-point interconnection wiring termination sheets and shall have served in a similar role on a project of similar size and complexity.
      1) Present qualifications and approach for the project at Pre-Construction Conference.
      2) Prepare the items listed below for presentation at the Pre-submittal Meeting. Submit to ENGINEER three weeks prior to date of meeting.
         a) List of projects where the Wiring Coordinator developed point-to-point wiring termination sheets.
         b) Samples of diagrams that were developed for the listed projects.
         c) Example wiring diagram proposed for the Work with a preliminary list of drawings to be produced.
         d) Plan of how information will be obtained and documented.
   b. Responsibilities:
      1) Develop point-to-point interconnection wiring termination sheets for performance of the Work and to document terminations.
      2) Use information obtained from approved Shop Drawings, Record Drawings and field inspections as required to complete the sheets.
      3) Attend Pre-submittal Meeting and periodic process control system coordination and progress meetings.
      4) Conduct point-to-point wiring checks to determine wires and terminations are per the point-to-point interconnection wiring termination sheets. CONTRACTOR to sign-off on the sheets to document the checks were performed. After confirmation by the CONTRACTOR, submit the signed sheets to the OWNER/ENGINEER.
   c. Point-to-Point Interconnection Wiring Termination Sheets: Include the following:
      1) External wiring for each piece of equipment, panel, instrument and other devices and conduit wiring to control stations, lighting panels and motor controllers.
      2) Numbered terminal block identification for each wire termination.
      3) Identification of the assigned wire numbers for all interconnections.
      4) Identification of all conduit wiring by the conduit tag in which the wire is installed.
      5) Terminal and pull boxes through which wiring is routed.
      6) Identification of all equipment and the Shop Drawing transmittal numbers for equipment from which the wiring requirements and termination information was obtained.

1.3 SUBMITTALS

A. Refer to other Division 01, General Requirements, and Division 26, Electrical, specification sections for submittal requirements.

B. Shop Drawings
   1. Shop Drawings shall include the following information to the extent applicable to the particular item:
      a. Manufacturer's name and product designation or catalog number, including environmental rating such as "Rated for Outdoor Use" or "Rated for Hazardous Location".

b. Electrical ratings.
c. Conformance to applicable standards or specifications.
d. Dimensioned plan, section, elevations and panel layouts showing means for mounting, conduit connection, and grounding.
e. Materials and finish specification, including paints.
f. Clearly identify all equipment and accessories proposed to be provided, including cross references to tag names as shown on the drawings.
g. List of components including manufacturer's names and catalog numbers.
h. Internal wiring diagram and drawings indicating all connections to components.
i. External wiring diagram showing numbered terminals and all external connections and wire requirements.

2. Electrical distribution equipment will not be approved until a preliminary power system analysis is complete, including available fault current study, coordination study, and arc-flash study.
3. Submit reports and test results in accordance with other Division 26, Electrical, sections.
4. For all seismic design systems submit a P.E. certification Form prepared, stamped and signed by a professional engineer, registered in the State of Utah, verifying that the design and details meet the loading requirements and are in accordance with all applicable codes.
5. Check shop drawings for accuracy and completeness prior to submittal. Shop drawings shall be stamped with the date checked and a statement indicating that the shop drawings conform to this Section and the Drawings. List all exceptions to the specifications and the Drawings. Include the complete associated specification section with each paragraph marked INCORPORATED or REJECTED in the submittal documents. Shop drawings not so checked and noted shall be returned marked NOT APPROVED.
6. The ENGINEER's review shall be for conformance with the design concept of the project and compliance with the Drawings. Errors and omissions on approved shop drawings shall not relieve the CONTRACTOR from the responsibility of providing materials and workmanship required by this Section and the Drawings.
7. All dimensions shall be field verified at the job site and coordinated with the work of all other trades.
8. Material shall not be ordered or shipped until the shop drawings have been approved. No material shall be ordered, or shop work started if shop drawings are marked "APPROVED AS NOTED - CONFIRM," "APPROVED AS NOTED - RESUBMIT" or "NOT APPROVED."

C. Operation and Maintenance Data

1. Submit operations and maintenance data for equipment furnished under this Division, in accordance with Division 01, General Requirements. The manuals shall be prepared specifically for this installation and shall include catalog data sheets, drawings, equipment lists, descriptions, parts lists including replacement part numbers.
2. Manuals shall include the following as a minimum:
   a. A comprehensive, linked, table of contents.
   b. Individually tabbed sections.
   c. Name, address, and contact information for supplier and local support office.
   d. A complete "As-Built" set of approved shop drawings.
   e. A complete list of the equipment supplied, including serial numbers, ranges and pertinent data.

f. A table listing of the "as left" settings for all timing relays and alarm and trip setpoints.
g. System schematic drawings "As-Built," illustrating all components, piping and electric connections of the systems supplied under this Section.
h. Detailed service, maintenance and operation instructions for each item supplied.
i. Special maintenance requirements particular to this system shall be clearly defined, along with special calibration and test procedures.
j. The operating instructions shall also incorporate a functional description of the entire system, with references to the systems schematic drawings and instructions.
k. Complete parts list with stock numbers, including spare parts.

1.4 PROJECT CLOSEOUT

A. Record Drawings shall accurately show the installed condition of the following items:
1. One line wiring diagram of the distribution system.
2. Accurate and detailed in place conduit and cable layouts with schedule of conduit sizes and number and size of conductors.
3. Underground raceway and duct bank routing and manhole and handhole locations with coordinates.
4. Layouts of the power and lighting arrangements and the grounding system.
5. Panel Schedule(s).
6. Lighting Fixture Schedule(s).
7. Grounding system wiring and components.
8. Control schematic diagrams, with terminal numbers and all control devices identified, for all equipment.
9. Point-to-Point Interconnection wiring diagrams with all terminals identified and all equipment, wire, and conduit tags indicated.
10. Provide wire and conduit schedules indicating identification tags; termination points; wire/cable types, quantity, sizes; and terminal equipment tags.
11. The Record Drawings shall reflect final equipment and field installation information.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Delivery of Materials: Instruct the manufacturers and vendors as to the maximum shipping sizes of equipment that can be accommodated at the site.

1.6 JOB CONDITIONS

A. Existing Conditions:
1. Examine the site and existing facilities in order to compare them with the Contract Documents with respect to the conditions of the premises, location of and connection to existing facilities and any obstructions which may be encountered.
2. Perform the Work with due regard to safety and in a manner that will not interfere with the existing equipment or in any way cause interruption of any of the functions of the plant.
3. The operation of existing facilities shall be maintained throughout construction. Any interruption of operation shall be approved by and coordinated with the owner.
4. Environmental conditions at the site are as follows:
a. Ambient air temperature: -23 to 38 degrees C (-10 to 100 degrees F)
b. Elevation: 4,550 feet (MSL).
c. Humidity: 80%

B. Limitations:
   1. Work shall be carried out with a minimum amount of disruption to the operation of the existing plant and with prior approval of OWNER. Submit for approval by OWNER, a detailed written procedure for work which affects operation of the existing plant, a detailed procedure for modifying any existing electrical equipment, including appropriate Personal Protective Equipment (PPE) required if equipment must remain energized while conducting work, anticipated time required to complete the Work, and the required shutdown time, if any.
   2. Work requiring interruption to the operation of existing facilities shall be approved a minimum of two weeks in advance. Any interruption lasting longer than permitted by the owner for a given process will require an alternate contingency to maintain operation, such as portable standby generators completely at the cost to the CONTRACTOR including procurement operation, fuel, and maintenance.
   3. Where the Work of CONTRACTOR ties in with existing installations, take prior precautions and safeguards in connecting the Work with the existing operating circuits so as to prevent any interruption to the existing operating circuits. The tying in of Work, installed under this Contract, with the existing circuits shall be performed only in the presence of OWNER. Advance notice will be required before any equipment is removed from service. Notify OWNER, in writing, of his intention to do such work, providing full details.

C. Structural Design Requirements:
   1. Provide structural design of electrical equipment, systems, and components, anchorage, and supports, including manufacturer's certifications, in accordance with General Product Requirements under Division 01, including seismic design.
   2. Design, furnish, and install complete anchorage systems in accordance with applicable codes for all electrical equipment specified in the appropriate sections in Division 26, Electrical. All hangers, supports, and appurtenances shall conform to the latest applicable requirements of the Local/State Building Code except as supplemented or modified by the requirements of this section. Support arrangements shall be coordinated to eliminate interference with similar support systems to be installed by HVAC, Plumbing and for Process Pipe supports.

D. Demolition:
   1. The demolition of electrical power distribution equipment, instrumentation/ control equipment, conduit, wire and appurtenances shall be in accordance with the specifications. All salvageable equipment shall be turned over to the OWNER and stored on site per OWNER requirements. All refuge must be hauled away and disposed of at CONTRACTOR's expense.

1.7 ENVIRONMENTAL RATINGS

A. Area Classifications:
   1. Materials and equipment shall conform to the area classification(s) shown on the Drawings, specified, and required.
   2. Materials identified below are the minimum required. The drawings may include additional requirements.
   3. Corrosive Locations: The following areas shall be considered corrosive locations:
      a. Chemical storage and pumping areas.
      b. Indoor process areas.
      c. Outdoor areas.
   4. Hazardous Locations:

a. Hazardous areas shall be as shown on the Drawings.
b. Equipment, materials and installation in areas designated as hazardous on the Drawings shall comply with NEC Articles 500, 501, 502 and 503.
c. Equipment and materials installed in hazardous areas shall be UL listed for the appropriate hazardous area classification.
d. Materials, equipment and incidentals in areas identified as hazardous locations shall meet NEC requirements for the Class and Division designated.
e. Devices that are not labeled for use in the hazardous area in which they are installed shall be wired from intrinsic safety barrier relays installed in accordance with NEC and UL requirements.

B. Enclosures, Cabinets, Panels, and Boxes:
1. All indoor DRY areas NEMA 12 gasketed.
2. All indoor WET areas NEMA 4X 316 Stainless Steel.
3. All indoor PROCESS areas NEMA 4X 316 Stainless Steel.
4. All CORROSIVE areas NEMA 4X 316 Stainless Steel.
5. All indoor CORROSIVE protected chemical storage and handling areas NEMA 4X non-metallic (polycarbonate only).
6. All OUTDOOR areas: NEMA 4X 316 Stainless Steel.
7. All FINISHED office areas NEMA 1.
8. HAZARDOUS classified areas: Listed and labeled suitable for the environment in which it is installed.
9. Outdoor enclosures with electronics and temperature sensitive instruments, shall be provided with sunshade structures and appropriately sized air conditioner, if required. Submit temperature calculations for each outdoor enclosure. Sunshade structures shall be constructed as shown on drawings.

C. Raceways, Conduits, and Fittings:
1. All indoor DRY areas: Galvanized Rigid Steel.
2. All indoor WET areas: PVC Coated Galvanized Rigid Steel.
3. All indoor PROCESS areas: PVC Coated Galvanized Rigid Steel.
4. All indoor CORROSIVE areas: PVC Coated Galvanized Rigid Steel.
5. Indoor MBR building and Blower building as indicated on the drawings: Aluminum conduit and rigid Galvanized Steel Ventilated Cable Tray.
6. All exposed OUTDOOR AREAS: Galvanized Rigid Steel.
7. All underground direct buried: Schedule 80 PVC.
8. All underground concrete encased or concrete capped: Schedule 40 PVC.
9. All FINISHED office areas (120V): Intermediate Metal Conduit. EMT may be used where conduit is concealed.
10. HAZARDOUS classified areas: Meet the NEC requirements for the environment in which it is installed.

D. Wires and Cables:
1. All Medium-Voltage wiring: MV105.
2. All Feeder wiring: RHW or XHHW-2.
3. All indoor power wiring: XHHW-2
4. All 120V indoor light and convenience receptacle circuits wiring: THWN.
5. Cable tray wiring in MBR building: Multi-conductor THHN/THWN type TC, stranded power and control wiring.
6. All other power wiring: XHHW-2.
7. 120 V control Wiring: THHW/THWN.

8. Specialty wires and cables as indicated in individual specification sections, as indicated on the drawings, or as recommended by associated equipment manufacturers, upon ENGINEER approval.

E. Electrical Equipment:
   1. All electrical equipment shall be capable of operating successfully at full-rated load, without failure, at the environmental conditions at the site..
   2. All electrical devices and equipment shall have ratings based on 75 degrees C (167 degrees F) terminations, minimum.
   3. Mounting of electrical equipment on handrails is not allowed.

F. Hangers and Supports
   1. All indoor DRY NON-PROCESS areas: Galvanized Steel.
   2. All indoor WET areas: 316 Stainless Steel.
   3. All indoor PROCESS areas: Powder Coated Steel.
   4. All indoor CORROSIVE areas: 316 Stainless Steel.
   5. All exposed OUTDOOR AREAS: 316 Stainless Steel.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 SLEEVES AND FORMS FOR OPENINGS

A. Provide and place all sleeves for conduits penetrating floors, walls, partitions, etc. Locate all slots for electrical work and form before concrete is poured.

B. Determine exact locations for concealed conduit stub-ups. Obtain shop drawings and templates from equipment vendors or other subcontractors and locate concealed conduits before the floor slab is poured.

C. Where setting drawings are not available in time to avoid delay in scheduled floor slab pours, the ENGINEER may allow the installations of such conduit to be exposed. Requests for this deviation must be submitted in writing. No additional compensation for such change will be allowed.

D. Seal all openings, sleeves, penetration and slots.

3.2 CUTTING AND PATCHING

A. Cutting and patching shall be done in a workmanlike manner and be in compliance with modifications and repair to concrete as specified in Division 01, General Requirements. Saw cut concrete and masonry prior to breaking out sections.

B. Core drill holes in concrete floors and walls as required.

C. Coordinate work at such time as to require the minimum amount of cutting and patching.

D. Do not cut joists, beams, girders, columns or any other structural members.

E. Cut opening only large enough to allow easy installation of the conduit.

F. Patching to be of the same kind and quality of material as was removed.

G. The completed patching work shall restore the surface to its original appearance or better.

H. Patching of waterproofed surfaces shall render the area of the patching completely waterproofed.

I. Remove rubble and excess patching materials from the premises.

J. When existing conduits are cut at the floor line of wall line, they shall be filled with grout of suitable patching material.

3.3 INSTALLATION

A. Work not installed according to the Drawings and Specification shall be subject to change as directed by the ENGINEER at CONTRACTOR's expense.

B. Electrical equipment shall be protected against mechanical and water damage. Store all electrical equipment in dry permanent shelters. Do not install electrical equipment in place until structures are weather-tight.

C. Damaged equipment shall be replaced or repaired by the equipment manufacturer, at the ENGINEER's discretion and at the CONTRACTOR's expense.

D. Repaint any damage to factory applied paint finish using touch-up paint furnished by the equipment manufacturer. The entire damaged panel or section shall be repainted at the CONTRACTOR's expense.

3.4 MANUFACTURERS SERVICE

A. Provide manufacturer's services for testing and start-up of the following equipment:
   1. 12.47 kV Switchgear (5 days 1 trip minimum)
   2. Pad Mounted Transformer (Dry-Type) (5 days 1 trip minimum)
   3. Substation Transformer (Liquid Filled) (5 days 1 trip minimum)
   4. 480 Volt Switchboard (5 days 1 trip minimum)
   5. 480 Volt Motor Control Centers (5 days 1 trip minimum)
   6. Fire Alarm System (5 days 1 trip minimum)
   7. Security Alarm System (5 days 1 trip minimum)
   8. Card Access Control System (5 days 1 trip minimum)
   9. Gate Security System (5 days 1 trip minimum)
   10. Perimeter Security System (5 days 1 trip minimum)
   11. Fiber Optic Network System (5 days 1 trip minimum)
   12. Adequate time shall be provided in the projects scope to provide testing and startup for equipment as listed above to deliver a fully functional system to the OWNER upon completion of the Work.

B. Testing and startup shall not be combined with training. Testing and start-up time shall not be used for manufacturer's warranty repairs.

3.5 TRAINING

A. Provide manufacturer's services for training of plant personnel in operation and maintenance of the equipment furnished under Division 26, Electrical.
   1. 12.47 Volt Switchgear (1 days 1 trip minimum)
   2. Pad Mounted Transformers (Dry-Type) (1 days 1 trip minimum)
   3. Substation Transformers (Liquid Filled) (1 days 1 trip minimum)
   4. 480 Volt Switchboard (1 days 1 trip minimum)
   5. 480 Volt Motor Control Centers (1 days 1 trip minimum)
   6. Fire Alarm System (1 days 1 trip minimum)
   7. Security Alarm System (1 days 1 trip minimum)
   8. Card Access System (1 days 1 trip minimum)
   9. Gate Security System (1 days 1 trip minimum)
   10. Perimeter Security System (1 days 1 trip minimum)
   11. Adequate training time shall be included in the project scope to provide two training sessions to train the OWNER’s electrical team on all equipment listed above for which they will be responsible to maintain. For high- and medium-voltage equipment that is to be maintained by Provo Power, an additional training session may also be required and is to be included in the project scope

B. The cost of training programs to be conducted with OWNER's personnel shall be included in the Contract Price. The training and instruction shall be directly related to the system being supplied.

C. Provide detailed O&M manuals to supplement the training courses. The manuals shall include specific details of equipment supplied and operations specific to the project.

D. The training program shall represent a comprehensive program covering all aspects of the operation and maintenance of each system.

E. All training schedules shall be coordinated with and at the convenience of the OWNER. Shift training may be required to correspond to the OWNER's working schedule.

F. Within 120 days of contract award to the CONTRACTOR, submit an overview of the proposed training plan. This overview shall include, for each course proposed:
   1. An overview of the training plan.
   2. Course title and objectives.
   3. Prerequisite training and experience of attendees.
   4. Recommended types of attendees.
   5. Course Content - A topical outline.
   6. Course Duration.
   7. Course Location - Training center or job site.
   8. Course Format - Lecture, laboratory demonstration, etc.
   9. Schedule of training courses including dates, duration and locations of each class.
   10. Resumes of the instructors who will actually implement the plan.

G. The ENGINEER will review the training plan submittal with the OWNER.

++ END OF SECTION ++

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SECTION 26 05 13

MEDIUM VOLTAGE CABLE

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install medium voltage cable and shall retain the services of an independent testing firm to perform acceptance testing of the cable installation. The cable shall be installed in conduits and cable trays.

1.2 QUALITY ASSURANCE

A. Requirements of Regulatory Agencies:
   1. Codes: Install cable in accordance with the current standards and recommendations of the National Electrical Code and with any applicable local codes. Where discrepancies arise between codes, the most restrictive regulation shall apply.
   2. Tests by Independent Regulatory Agencies: Cable shall bear the label of the Underwriters' Laboratories, Incorporated.
   3. Utilities:
      a. Work in connection with the utility service shall be done in strict conformance with the requirements of Provo Power and Rocky Mountain Power guidelines.

B. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified.
   1. National Electrical Code (NEC) current adoption.
   2. ASTM B3, Uncoated Annealed Copper Conductors.
   3. ASTM B8, Specification for Concentric Lay Stranded Copper Conductors.
   4. ASTM B33, Tin Coated Conductors.
   5. ASTM B189, Lead or Alloy Coated Conductors.
   6. ASTM B230, Aluminum, 1350-H19 Wire for Electrical Purposes.
   7. ASTM B231, Aluminum 1350 Conductors, Concentric-Lay-Stranded.
   8. ASTM B609, Aluminum 1350 Round Wire, Annealed and Intermediate Tempers, for Electrical Purposes.
   9. UL 1072, Revised Outline of Requirements for Medium Voltage Cables.
   10. ANSI C2, National Electrical Safety Code.
   11. NETA, InterNational Electrical Testing Association.
   12. IEEE 48, Standard Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5 KV through 765 KV.
   13. IEEE 404, Standard for Cable Joints for use with Extruded Dielectric Cable Rated 5000-138,000 V and Cable Joints for use with Laminated Dielectric Cable Rated 2500-500,000 V.

C. The general construction of the cable and the insulation material used shall be similar to that used for cable of the same size and rating in continuous production for at least 20 years and successfully operating in the field in substantial quantities.

D. Factory Production Tests:

1. Conductors shall meet the electrical resistance requirements of ICEA-69-516 Section 2.5.
2. Final Voltage and Insulation Resistance Test: The completed cable, while on the shipping reel, shall be tested at room temperature at a minimum of 25 KVDC for one minute. Insulation Resistance test shall be performed in accordance with the requirements of ICEA S-68-516, Part 6.28. Each cable shall have an insulation resistance not less than that corresponding to the insulation resistance constant of 20,000 megohms per 1000 feet at 15.6 degrees C (60 degrees F).
3. Qualification Discharge Resistance Test: A high voltage AC and DC test shall be performed in accordance with Part 6.27 of ICEA S-68-516. The AC and DC test voltages shall be in accordance with Section B of AEIC CS6.
4. Shield resistance shall be measured and recorded from end to end on the completed cable.
5. Corona Test: Each reel of completed shield power cable shall be partial discharge tested in accordance with Sections E and F of AEIC CS6.
6. Energy Suppression Layer Test: The inner energy suppression layer shall be tested during manufacture at 1 KV DC test between electrodes and conductor to prove its electrical integrity. Dielectric breakdown indicating a weakness in this layer shall be eliminated by cutting the cable at the failure point or stripping of the entire manufacturing length and re-insulating.

E. Testing Firm Qualifications: The independent testing firm shall have experience in the inspection and testing of cables of the type specified and shall be NETA certified.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
1. Manufacturer's catalog cuts and technical information indicating compliance with this Section. Any exceptions shall be stated and completely explained.
2. Literature identifying the methods and materials which CONTRACTOR proposes to use to make splices and terminations. Submittal shall consist of manufacturers' literature evidencing compatibility of the conductor insulation, shield and jacket of the cable with the splicing or terminating materials and methods which CONTRACTOR proposes to use.
3. Listing of cable sizes to be furnished.
4. Listing of locations where splices are proposed.
5. Qualifications of splicing and termination personnel and testing firm.

B. Test Reports: Submit for approval copies of factory tests and field acceptance testing. Acceptance testing procedures shall be submitted in advance prior to actual testing. Test reports shall indicate results of all testing.

C. Record Drawings: Include the actual location and routing of all installations of medium voltage cables on Record Drawings in accordance with the specifications.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Cable insulation shall be thermosetting rubber-based ethylene propylene rubber (EPR) compound over an extruded, non-conducting high dielectric stress control strand screen layer, with a semi-conducting screen layer applied directly over the

primary

insulation. Medium voltage cable shall be shielded unless specifically shown otherwise on the Drawings. Concentric neutral where shown on the drawings. Suitable for normal installation, indoors or outdoors, in conduit, in air, and intermittent or continuous submersion in water, in underground duct systems, and direct buried installation. Cable for use in cable tray (for all or part of run) shall be UL listed "Type MV 105 for TC use".

B. Cable Ratings:
   1. 5 kV Cable
      a. Cable type: Single conductor.
      b. Insulation level as required as required by UL 1072: 115 mils/133 percent.
      c. Operating voltage; 4160 V, 3 Ph, 60 Hz, grounded distribution system.
   2. 15 kV Cable
      a. Cable type: Single conductor.
      b. Insulation level as required as required by UL 1072: 220 mils/133 percent.
      c. Operating voltage; 12,470 V, 3 Ph, 60 Hz, grounded distribution system.

C. MV-105 Materials:
   1. Cable shall be single conductor bearing UL label "Type MV 105" and comply with or exceed ICEA S-693-639 and AEIC S-97-682.
   2. Conductors: All conductors shall be aluminum with concentric-lay Class B round stranding in accordance with the current ASTM Standard B800 and B836.
   3. Insulation System: The insulation system shall be composed of an extruded inner layer of non-conducting energy suppression or semi-conducting material. The primary insulation shall be a high quality ozone resistant thermosetting rubber based compound. The insulation system shall be suitable for use at conductor temperatures not exceeding 105 degrees C (221 degrees F) for normal operation, 140 degrees C (284 degrees F) for emergency overload conditions, and 250 degrees C (482 degrees F) for short circuit conditions. The minimum thickness at any part of the cable shall not be less than 90 percent of the specified average.
   4. Insulation Screen: Insulation screen shall be extruded, strippable, semi-conducting, cross-linked copolymer applied directly over the insulation.
   5. Insulation Shield: The insulation shield shall consist of a copper tape applied helically with 12.5 percent nominal overlap. Embedded drain wires are not acceptable
   6. Neutral: 33% concentric neutral with mylar tape shield where shown on the drawings.
   7. Jacket: A continuous jacket of moisture, heat, oil resistant black polyvinyl chloride shall be applied over the insulation and shielding system. Cables for use in cable tray shall have a jacket of vulcanized, chlorosulfonated polyethylene. The average minimum thickness of the jacket at any point of the cable shall not be less than 60 mils.
   8. Product and Manufacturer: Provide one of the following:
      a. Okonite Company
      b. General Cable
      c. SouthWire
      d. Or engineer approved equal

D. MV-90 Materials:
   1. Cable shall be single conductor bearing UL label "MV 90" and comply with or exceed ICEA S-93-639 and AEIC CS6-87.
   2. Conductor: All conductors shall be aluminum with concentric-lay Class B round stranding in accordance with the current ASTM Standards B 8, and either B 33 or B 189.

3. Insulation System: The cable insulation system shall include two separate shield layers and the primary insulation.
    a. Conductor shield shall consist of an extruded inner layer of non-conducting energy suppression or semi-conducting material.
    b. Primary insulation shall be a high quality ozone resistant ethylene-propylene rubber based compound. The insulation system shall be suitable for use at conductor temperatures not exceeding 90 degrees C (194 degrees F) for normal operation, 130 degrees C (266 degrees F) for emergency overload conditions, and 250 degrees C (482 degrees F) for short circuit conditions. The minimum thickness at any part of the cable shall not be less than 90 percent of the specified average.
    c. Insulation shield shall be an outer layer of semi-conducting material consisting of a five mil copper tape applied helically with a minimum 12-1/2 percent overlap.
4. Jacket: A continuous jacket of moisture, heat, oil resistant black polyvinyl chloride shall be applied over the insulation and shielding system. The average minimum thickness of the jacket at any point of the cable shall be in accordance with ICEA S-93-639 Table 4-3.
5. Product and Manufacturer: Provide one of the following:
    a. Okonite Company
    b. General Cable
    c. SouthWire
    d. Or engineer approved equal

E. Cable Connectors:
1. All connectors shall be copper, tin-plated, long barrel compression type. Suitable for voltage applications up to 35 KV.
2. For sizes 250 MCM and larger, connectors shall be two-hole mount type with provisions for two bolts for joining to apparatus terminal.
3. Product and Manufacturer: Provide one of the following :
    a. HYLUG – Burndy by Hubbell
    b. Thomas & Betts
    c. Or engineer approved equal

F. Cable Terminations:
1. All cable terminations shall meet Class 1 requirements of IEEE 48.
2. Terminations shall be of the molded elastomer heat-shrinkable types or cold shrink types, with grounding provisions for the cable shielding.
3. Product and Manufacturer: Provide one of the following :
    a. Elastimold – Thomas & Betts
    b. G&W Electric Company
    c. Raychem Coporation
    d. 3M Company
    e. Or engineer approved equal

G. Cable Splices:
1. All cable splices shall be made using standard splice kits which reinstate the cable's insulation and jacket, and continue the metallic shielding through the entire cable joint.
2. Splices shall be premolded, conventional tape, cold shrink type, or heat-shrinkable type.
3. Product and Manufacturer: Provide one of the following :
    a. Elastimold – Thomas & Betts
    b. G&W Electric Company

c. Raychem Corporation
d. 3M Company
e. Or engineer approved equal

H. Indoor Cable Termination (5 and 15 kV)
1. Single conductor shielded cable terminations for indoor applications shall be one piece, track resistant EPDM rubber with top seal and ground strap assemblies.
2. Termination shall have a current rating equal to, or greater than the cable ampacity.
3. Termination shall accommodate any form of cable shielding or construction without the need for special adapters.
4. Product and Manufacturer: Provide one of the following :
a. Cold Shrink Quick Term QT III, 7620-T Series – 3M Company
b. HVT Series – Raychem Corporation.
c. Elastimold – Thomas & Betts
d. Or engineer approved equal

I. Outdoor Cable Terminations (5 and 15 kV)
1. Single conductor shielded cable terminations for outdoor protected or exposed locations shall be one piece, track resistant silicone rubber with top seal, rain skirt and ground strap assemblies. Cable compartments of outdoor metal clad switchgear shall be considered as outdoor locations.
2. Termination shall have a current rating equal to, or greater than the cable ampacity.
3. Termination shall accommodate any form of cable shielding or construction without the need for special adapters.
4. Product and Manufacturer: Provide one of the following :
a. Cold Shrink Quick Term QT III, 7620-S Series – 3M Company
b. HVT Series – Raychem Corporation
c. Elastimold – Thomas & Betts
d. Or engineer approved equal

J. Single conductor 25/35 kV shielded cable terminations for indoor or outdoor applications:
1. Product and Manufacturer: Provide one of the following:
a. Elastimold, 35 MTG Series
b. 3M Company 25 KV QT III 7690–T Series (Indoor) or QT III 7690-S (Outdoor); 35 KV QT III 7680-S (Outdoor)
c. Or engineer approved equal

K. Single conductor 15/25/35 kV concentric neutral cable terminations:
1. Product and Manufacturer: Provide one of the following:
a. 3M Company, Cold Shrink 7640-T Series (Indoor), Cold Shrink 7640-S Series (Outdoor), except where load break elbows are specified in the specifications.
b. Or engineer approved equal

L. Tape Shielded Inline and Tee and Multi-point Cable Splice
1. Splice all shielded cables rated 15,000 V or less with conductor sizes ranging from No. 4 to 1,000 Kcmil in accordance with the instructions provided with inline cold shrink splice kits.
a. Product and Manufacturer: Provide one of the following :
1) QS-III – 3M Company
2) Scotch Brand Tape Splicing Kits 5717, 5718, 5719 and 5720
3) CAS Series – Raychem Corporation
4) Or engineer approved equal

2. Shielded cable splices shall be capable of normal continuous operations at the rated voltage and current on the cable it is to be used on (15 kV maximum). The splice kit shall contain all of the necessary materials required to make three splices including cable preparation materials, such as solvents, rags and abrasive materials. The primary insulating tape shall be an all-voltage linerless tape. A comprehensive step-by-step instruction sheet shall be included with each kit.
3. 25 and 35 kV cable splices shall be made in accordance with splice drawings furnished by the cable manufacturer.
4. Separable connector system 600 AMP, 15/25kV Class; 4 point junction, rack installation in accordance with the instructions provided with the connector system.
    a. Product and Manufacturer: Provide one of the following:
        1) 5810/5811 Loadbreak Series – 3M Company
        2) 5815 Modular Technology Series – 3M Company
        3) Raychem
        4) Elastimold – Thomas & Betts
        5) Or engineer approved equal

M. Transition Splices
1. Splice transition from PILC to EPR cables shall utilize an oil stop design.
2. Product and Manufacturer: Provide one of the following
    a. Adalet, Type 35TT
    b. MAC Products, Type RP1T/RP3T
    c. 3M Company QS-2000T Series
    d. Or engineer approved equal

N. Heat Shrinkable Bus Connection Kits
1. Bus kits shall be capable of insulating bus bars 2-in to 6-in wide and for connection of one to four cables. Kits shall electrically insulate and environmentally seal the connection and be easily re-enterable.
2. Cable-to-bus bar connection kits shall be rated up to 15 kV class and tested in accordance with ANSI C37.20c, Section 5.2.1.4 Test for Bus Bar Insulation and Section 5.2.9 Flame-Retardant Test for Applied Insulation.
    a. Product and Manufacturer: Provide one of the following :
        1) Type HVBC – Raychem Corporation
        2) 3M Company
        3) Elastimold – Thomas & Betts
        4) Or engineer approved equal

O. Medium Voltage Motor Connection Kits.
1. Motor connection kits shall insulate the motor feeder motor lead connection and allow installation within the motor conduit box.
2. Kits shall environmentally seal the connection and be easily re-enterable.
    a. Product and Manufacturer: Provide one of the following:
        1) Type MCK – Raychem Corporation
        2) 5300 Series – 3M Company
        3) Or engineer approved equal

P. Cable end caps shall be heat shrinkable polyelofin
1. Product and Manufacturer: Provide one of the following
    a. 3M Company Type SKE
    b. Or engineer approved equal

Q. Lugs and Connectors

1. Copper lugs and connectors shall be crimped with standard industry tooling. All connections of copper stranded wire in sized No. 6 AWG through 1000 kcmil shall be made electrically and mechanically secured. The lugs and connectors shall have a current carrying capacity equal to the conductors for which they are rated and meet UL 486 requirements. Lugs larger than 4/0 AWG shall be two-hole lugs with NEMA spacing. The lugs and connectors shall be rated for operation through 35 kV. The lugs shall be of closed end construction to exclude moisture migration into the cable conductor.

R. Electrical Grounding Braid
   1. Conducting metal braid shall be woven from 240 strands of 30 AWG tinned copper wires and be capable of carrying fault current comparable to that of 6 AWG copper wire.
   2. Product and Manufacturer: Provide one of the following
      a. 3M Company Scotch braid 25, or equal
      b. Or engineer approved equal

S. Cable Marking Systems
   1. A 7-mil, flame retardant, cold and weather-resistant vinyl plastic electrical tape shall be used for phase identification, 3M Company Scotch 35 Tape, or equal.
   2. Cable tags shall be heat stamped nylon secured by polypropylene cable ties.
   3. Product and Manufacturer: Provide one of the following:
      a. Thomas & Betts No. TC228-TB
      b. Or engineer approved equal

T. Separable Surge Arresters
   1. MOV surge arresters with IEEE 386 interface, fully shielded, fully submersible, 15kV Class.
   2. Product and Manufacturer: Provide one of the following
      a. Type PSA Elastimold
      b. Or engineer approved equal

2.2 SECTIONALIZER CABINETS

A. Construction
   1. Cable sectionalizing centers with 600A, 15kV class loadbreak connector systems.
   2. continuous seam-welded and manufactured of 12-gauge mild steel.
   3. Top hinged removable cover with a wind stop to prevent accidental closing.
   4. Configured for one person operation.
   5. 3/8” ground bar installed.

B. Product and Manufacturer: Provide one of the following:
   1. Eaton Cooper Power Systems
   2. Or engineer approved equal

2.3 PULLING COMPOUNDS

A. Pulling compound shall be nontoxic, nonflammable, noncombustible and noncorrosive. The material shall be UL listed and compatible with the cable insulation and jacket.
   1. Product and Manufacturer: Provide one of the following:
      a. Ideal Industries
      b. American Polywater Corporation
      c. WL Series - 3M Company

d. Or engineer approved equal

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all cables complete with proper terminations at both ends. Check for proper phase sequence and proper motor rotation.

B. Splice and terminate all medium voltage cables in strict accordance with the cable manufacturer's recommendations.
   1. Use experienced personnel familiar with the materials and procedures to be employed.
   2. Make splices watertight in all cases below grade and submersible in all manholes and handholes.

C. Pulling:
   1. Use insulating types of pulling compounds containing no mineral oil.
   2. Limit pulling tension within values recommended by the cable manufacturer.
   3. Use a dynamometer where mechanical means are used.
   4. Cut off section subject to mechanical means.

D. Bending Radius: Limit to 12 times cable overall diameter.

E. Slack: Provide maximum slack without coiling at terminal points and in manholes.

F. Wrap cables located within manholes, handholes and boxes with fireproofing tape for their entire length on an individual cable basis. Tape shall be 30 mils thick of self-extinguishing material which will not support combustion. Tape shall not deteriorate when subjected to water, salt, sewage or fungus and shall be secured with glass cloth tape. Fireproof cables in accordance with the cable manufacturer's recommendations and then cover with tape extending at least 1-inch into any duct.

G. Identification: Identify all conductors by circuit number and phase at each terminal and splice location. Plastic nameplates shall be installed in each manhole, pull box and at splice and terminating points. These nameplates shall show the phase and feeder designations and the date when the cable was installed or splice or termination was made. The feeder designation shall be as indicated on the Drawings. Nameplates shall be tied to each cable with self-locking nylon ties.

H. Color code cables in accordance with OWNER’s standard.

3.2 TESTING

A. Perform acceptance testing of the medium voltage cable system. Each medium voltage cable circuit shall be inspected and tested on an individual per phase basis. All testing and inspection shall be performed by an independent certified testing firm.

B. Visual and Mechanical Inspection: Perform inspection of each power cable installation in accordance with the latest NETA acceptable testing specifications. All splices and terminations shall be inspected.

C. Electrical Tests: Perform electrical testing of each power cable in accordance with the latest NETA testing procedures. Testing shall include the following:
   1. Shield continuity test.
   2. DC high potential test.
   3. Adhere to following procedures before performing DC over potential tests:
      a. Disconnect all equipment including but not limited to transformers, switches, motors, circuit breakers and surge arrestors, from cable circuit to prevent test interruptions due to flashovers or trip outs resulting from excessive leakage current.
      b. Establish adequate clearance between the circuit test ends and any grounded object and to other equipment not under test.
      c. Ground all circuit conductors not under test, all cables shields and nearby equipment.
      d. Clean insulation surfaces.
      e. Keep cable ends dry.
   4. Apply high-potential slowly in eight to ten equal steps to 80 percent of the manufacturer's test value. Record the leakage current at each test voltage and plot the curve on graph paper.
   5. Stop test if the leakage current increases excessively or a "knee" appears in the curve before reaching maximum test voltage.
   6. Upon reaching the specified maximum test voltage, maintain the voltage for 15 minutes, record the leakage current at 30 seconds and one minute and at one minute intervals thereafter. Plot leakage current versus time on the same graph as the step voltage curve.
   7. Reduce conductor test potential to zero and measure residual voltage at discrete intervals.
   8. Apply ground for a time period adequate to drain charges stored in the insulation.
   9. Cable failing the test shall be repaired or replaced and retested. If a test failure occurs on a cable interconnected to an existing cable, notify ENGINEER for further instructions.
   10. The test curves shall be signed by the tester, initialed by OWNER'S representative and shall be sent to ENGINEER for review.

D. Where existing cables are spliced to cables provided under this Contract, the new cables shall be DC high-potential tested prior to splicing. After approval of the new cable test, the splicing shall be made and the entire cable shall be insulation-resistance tested. A shield continuity test shall also be performed. When these tests prove positive, a DC high-potential test shall be performed. Test voltage and procedures shall be in accordance with the latest NETA recommendations. Any cable failure shall be brought to the ENGINEER'S attention.

++ END OF SECTION ++

SECTION 26 05 26

GROUNDING AND BONDING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install complete grounding for the electrical systems, structures and equipment.
   2. Ground rods, building steel, structural rebar, duct bank ground wires, and Pump cans and buried piping shall be bonded to the ground grid.
   3. Neutral bonding shall be provided for all transformers, generators and other separately derived systems, and where shown on the drawings.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified:
   1. National Electrical Code (NEC) Article 250, Grounding.
   2. 2. Underwriters Laboratories (UL) Standard No. 467, Electrical Grounding and Bonding Equipment.
   3. 3. ANSI-J-STD-607-A, Commercial Building Grounding [Earthing] and Bonding Requirements for Telecommunications.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's technical information for grounding materials proposed for use, including round wires, rods, test wells, and connectors.
   2. Listing of grounding connector types identifying where they are to be used.
   3. Layouts of each structure ground grid.
   4. Test point construction details.
   5. Ground resistance test procedure.
   6. Results of ground resistance tests at each test point.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Ground Wire: Annealed, bare, stranded copper per ASTM B8 or solid per ASTM B 3. Bonding conductor shall be No. 4 or No. 6 AWG stranded.
   1. Product and Manufacturer: Provide one of the following:
      a. Southwire Company
      b. Service Wire Company

c. Encore Wire Corporation
d. Or engineer approved equal

C. Ground Rods:
1. Material: Copperclad rigid steel rods, 3/4-inch diameter, 10 feet long, one piece.
2. Product and Manufacturer: Provide one of the following:
a. Erico
b. A.B. Chance Company – Hubbell
c. South Atlantic LLC
d. Harger Lighting & Grounding
e. Or engineer approved equal

D. Grounding Connectors:
1. Material: Pressure connectors shall be copper alloy castings, designed specifically for the items to be connected, and assembled with Durium or silicone bronze bolts, nuts and washers. Welded connections shall be by exothermic process utilizing molds, cartridges and hardware designed specifically for the connection to be made.
2. Product and Manufacturer: Provide one of the following:
a. Pressure Connectors:
1) O.Z./Gedney - Emerson
2) Burndy – Hubbell
3) Or engineer approved equal
b. Welded Connections:
1) Cadweld – Erico
2) Therm-O-Weld by Continental Industries – Hubbell
3) Or engineer approved equal

E. Concrete Boxes:
1. Material: High density reinforced concrete box with non-settling shoulders positioned to maintain grade and facilitate back filling with steel checker plate screw down cover.
2. Size:
a. Outside Locations: 15 x 22 inches, minimum.
b. Inside Locations: 10 x 17 inches, minimum.
3. Product and Manufacturer: Provide one of the following:
a. Concrete Box:
1) Christy Box Model B1017 – Oldcastle Infrastructure
2) Or engineer approved equal
b. Steel Cover:
1) Christy Box Cover Model B1017-51JH labeled "GROUND" – Oldcastle Infrastructure
2) Or engineer approved equal

F. Bare Grounding Conductor and Conductor Protector for Wood Poles:
1. No. 4 AWG minimum, soft-drawn copper.
2. Conductor Protector: Half-round PVC or wood molding. If wood, use pressure-treated fir or cypress or cedar.

G. Grounding Bus: Rectangular bars of annealed copper, 1/4 by 2 inches in cross section, unless otherwise indicated; with insulators.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.

B. Conductor Terminations and Connections:
   1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
   2. Underground Connections: Welded connectors, except at test wells and as otherwise indicated.
   3. Connections to Ground Rods at Test Wells: Bolted connectors.
   4. Connections to Structural Steel: Welded connectors.

C. Ground Bar: Provide a ground bar in the electrical rooms Connect all equipment to ground bus. Provide 2 jumpers from ground bus to ground ring sized according to the grounding electrode size on the drawings.

3.2 STRUCTURE GROUND SYSTEM

A. Provide ground grids as shown on the Drawings.

B. Install a copper ground bus mounted to the wall in the electrical room as shown on the drawings.

C. Install No. 4/0 AWG bare copper cable. Install the cable around the exterior perimeter of structures, minimum 2 feet, 6 inches below grade, unless otherwise shown on the Drawings.

D. Install ground rods where shown on the Drawings. Install additional ground rods, if necessary, to attain a resistance to ground of less than five (5) ohms for each ground grid.

E. For structures with steel columns, install 4/0 AWG ground cable. Install cable from grid to each column around the perimeter of the structure. Connect cable to steel using exothermic welds.

F. Connect grids to a continuous underground water pipe system, when practical.

G. Provide concrete ground test wells for measuring the ground resistance of each separately derived power source, including generators, prior to terminating in equipment. Provide 12-inch ground conductor slack loop in each well. Route ground conductor from test well to equipment in PVC conduit.

H. Weld all buried connections. Test points connections shall utilize pressure connectors.

3.3 EQUIPMENT GROUNDING

A. Ground all electrical equipment in compliance with the National Electrical Code.

B. Equipment grounding conductors shall be bare stranded copper cable of adequate size installed in metal conduit where necessary for mechanical protection. Ground

conductors, pulled into conduits with non-grounded conductors, shall be insulated. Insulation shall be green.

C. Panel Grounding:
   1. A minimum size of 4/0 AWG bare stranded copper cable shall be installed between the ground grid and the panel enclosure grounding lug. The mounting frame for panels shall be grounded to the ground grid.
   2. A minimum size of 6 AWG insulated green stranded copper cable shall be installed between the ground grid and the isolated DC Ground Bus located on the enclosure sub-panel. This ground shall be installed in all panels that provide an isolated DC Ground Bus.

D. A separate green insulated ground conductor sized per conduit schedule as shown on DRAWINGS or NEC requirements shall be pulled into conduits and connected utilizing grounding conduit bushings.

E. Connect ground cable to piping by welding or brazing. Use copper bonding jumpers on all gasketed joints. Mechanical grounding clamps may be used.

F. Connect ground cable to equipment by means of lug compressed on cable end. Bolt lug to equipment frame using holes or terminals provided on equipment specifically for grounding. Do not install with hold down bolts. Where grounding provisions are not included, drill suitable holes in locations designated by ENGINEER.

G. Connect to motors by bolting directly to motor frames, not to sole plates or supporting structures.

H. Connect to service water piping by means of copper clamps. Use copper bonding jumpers on gasketed joints.

I. Ground all electrical and mechanical equipment frames to ground. Connect outdoor metallic equipment and tank frames to a ground rod or an adjacent ground ring.

J. Connect surge protective devices to ground.

K. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

L. Scrape bolted surfaces clean and coat with a conductive oxide- resistant compound.

M. Test all system grounding conductors for continuity of connection and electrical equipment. Provide in the final report a statement on equipment that was tested and document any discrepancies noted during the tests.

3.4 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished

floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Seal floor opening with waterproof, nonshrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.5 INSTALLATION

A. Grounding Conductors: CONTRACTOR to determine efficient route along shortest and straightest paths possible, unless otherwise indicated or required by Code.

B. Bonding Grounding system with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor and install in conduit.

C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade, unless otherwise indicated. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.

D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Install at least one test well for each service, unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
   1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
   2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
   3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

F. Bonding and Grounding for Fencing: For fencing around substations or electrical gear provide listed bonding connectors on each fence post. Connect to area ground grid with minimum #4/0 SDBC grounding conductors. Provide flexible, listed bonding straps across

all hinges on all fence gates. Measure resistance to ground using fall-of-potential method and provide OWNER with certified test results.

G. Grounding and Bonding for Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

H. Grounding for Steel Building Structure: Exothermically bond ground grid to building steel at locations shown on the drawings.

I. Ground Ring: Install a grounding ring around building or steel structures as shown on the drawings.
   1. Install tinned-copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel.
   2. Bury ground ring not less than 24 inches from building foundation.

J. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70, using a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.
   1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.
   2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to grounding electrode external to concrete.

3.6 GROUND GRID TESTING

A. The CONTRACTOR shall contract the Testing Firm to provide testing of the grounding electrode system as shown on drawings.
   1. Performing the following ground single point test:
      a. Conduct test at the testing point(s) locations as shown on the drawings using a clamp-on ground tester.
   2. Utilize the following test equipment:
      a. Fluke, Model 1625 Kit or equal.
      b. Visually inspect the installed ground reference electrode or ground rods. Verify that they are intact and accessible. Measure the ground system at these test points with the clamp-on meter. The results shall be recorded and submitted for OWNER approval.
      c. Proved a Serial Key number for each test point shown on the DRAWINGS. Coordinate with OWNER to determine the Serial Key number. Update the RECORD DRAWINGS with the Serial Key number.
      d. Install metal ground test point tags identified with a Serial Key number at each test point using stainless steel wire and zinc wire clamps. For any test points within equipment, attach test point tag to exterior of equipment with epoxy.
      e. Digitally Photograph clamp-on meter in place during test and include with test data sheets. Digital images shall have the Serial Key identified for reference. Digital images of these test points with the clamp-on tester in place are to provide a visual representation of the proper clamp-on testing placement and method and shall be inserted into the ground test sheet document.

B. Install grounding test tags for each grounding test. Provide the following for each tag. Install tag with epoxy if unable to utilize wire and clamp.

C. Tests shall be witnessed by the ENGINEER and OWNER.

++ END OF SECTION ++

SECTION 26 05 43

UNDERGROUND DUCTS AND RACEWAYS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Furnish and install underground duct banks including all labor, materials, equipment and incidentals as shown on the Drawings and specified for a complete system.

B. Coordinate installation with piping and other underground systems and structures. Provide supports for traversing existing underground facilities.

C. Provide bases for pad mounted electrical equipment per Provo Power Commercial Reference Book, Provo City Power Standards.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the National Electrical Code.

B. Materials shall be UL listed where applicable.

1.3 SUBMITTALS

A. Submit the following:
   1. Plans showing the proposed routing of duct banks and the locations of manholes, handholes and indicate burial depth and duct bank construction at each location.
   2. Profiles of duct banks showing crossings with piping and other underground systems.
   3. Typical cross sections.
   4. Concrete pad and vault information:
      a. Detailed drawings
      b. Structural calculations
      c. Catalog information:
         1) Manholes, hand holes, and vaults
         2) Vault accessories

B. Record Drawings: Include the actual routing of underground duct runs on Record Drawings.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Duct: Schedule 40 PVC conduit and fittings. Fiberglass conduit in non-traffic areas may be acceptable where permitted by the owner. Fiberglass conduit shall be UL 2420 listed for below ground installations, Reinforced Thermosetting Resin Conduit (RTRC), resin

system shall be epoxy based, with no fillers, using an anhydride curing agent. The fiberglass shall consist of continuous E-glass Grade "A" roving

B. Provide red colored concrete cap and warning tape over all duct banks. Concrete cap shall extend 3 inches beyond edge of outside conduits.

C. Exposed: PVC Coated Galvanized Rigid Metal Conduit: PVC coated rigid metal conduit and fittings.

D. Backfill: Select electrical duct bank backfill in accordance with the specifications. Backfill material around duct bank conduits must have a thermal resistivity less than 90°C cm/W.

E. Reinforcement: In accordance with the specifications.

F. Concrete: In accordance with the specifications.

G. Padmounted transformer and Padmounted Switchgear pad and Vault in accordance with Provo Standard "Services Larger than 800 Amp 3 Phase Transformer Pad Specification."

H. Sectionalizer pad in accordance with Provo Standard "Underground Distribution Specification (3 Phase)."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install outdoor equipment pads such that the electrical terminals are 3 feet above finished grade minimum.

B. Separation of Duct Banks systems:
   1. The following systems shall be routed in separate duct banks:
      a. Control and signal 48 V and less.
      b. Power and control 120 V.
      c. Power greater than 120V and less than 1000 V.
      d. Power 1000 V and greater.
   2. The following systems shall be routed in separate hand holes and manholes:
      a. Control and signal 48 V and less and power and control 120 V.
      b. Power greater than 120 V and less than 1000 V.
      c. Power 1000 V and greater.
      d. Manholes shall be sized as shown on the contract drawings.

C. All bends (vertical and horizontal) of 45 degrees or more require PVC coated rigid metal conduit or fiberglass conduit.

D. Excavation and backfilling required for duct bank installation.

E. All duct bank installations and penetrations through foundation walls shall be watertight and in accordance with the specifications.

F. Top of duct banks shall be as follows:

1. 1000V and below - minimum of 24 inches below grade, unless otherwise approved by the ENGINEER.
2. Greater than 1000V – 48 inches below grade.
3. Duct banks may vary for short distances to avoid underground interferences as approved by the ENGINEER.

G. Assemble duct banks using non-magnetic saddles, spacers and separators. Position the separators to provide 3 inches minimum concrete separation between the outer surfaces of the ducts. Side forms are only required to prevent excessive widening of the duct bank where over excavation has occurred.

H. Provide a 3-inch minimum concrete covering on sides, top and bottom of concrete envelopes around conduits. Concrete covering size shall be as shown on the Drawings. Add red oxide to concrete for easy identification during subsequent excavation. The red oxide is to be added in the concrete truck prior to the concrete being placed. Red oxide concrete shall include the entire duct bank, top and bottom unless under a slab.

I. Firmly fix ducts in place during placing of concrete. Carefully place and vibrate the concrete to ensure filling of all spaces between ducts.

J. Conduits entering floor mounted equipment, such as, switchgear compartments, motor control centers, transformers shall terminate with PVC coated rigid metal conduit factory 90º elbows, RNC risers and bell ends.

K. Reinforce all duct banks.
1. Unless otherwise shown on the Drawings, reinforce with No. 4 longitudinal steel bars placed at each corner and along each face at a maximum parallel spacing of 18 inches on centers, and No. 3 tie-bars transversely placed at 18 inches maximum longitudinal intervals. Overlap of No. 3 tie-bars shall be a minimum of 4-inches.
2. Maintain a maximum clearance of 1 inch from bars to the edge of the concrete encasement.
3. Install dowel reinforcement rebar where duct bank meets other concrete structures.

L. Do not backfill with material containing large rock, paving materials, cinders, large or sharply angular substances, corrosive material or other materials which can damage or contribute to corrosion of ducts or cables or prevent adequate compaction of fill.

M. Slope duct runs for drainage toward manholes and away from buildings with a slope of approximately 3 inches per 100 feet.

N. Install a bare stranded copper duct bank ground cable (4/0 or as shown on drawings) in each duct bank envelope. Make ground electrically continuous throughout the entire duct bank system. Connect ground cable to building and station ground grid or to equipment ground buses. In addition, connect ground cable to steel conduit extensions of the underground duct system. Provide ground clamp and bonding of each steel conduit extension, where necessary to maintain continuity of the ground system. Terminate ground cable at last manhole or handhole for outlying structures.

O. After completion of the duct bank or utilizing existing ducts and prior to pulling cable, pull a mandrel, not less than 12 inches long and with a cross section approximately 1/4 inch less than the inside cross section of the duct, through each duct. Then pull a rag

swab or sponge through to make certain that no particles of earth, sand or gravel have been left in the duct.

P. Pulling Rope/Tape
   1. Pulling rope or tape shall be constructed of polyester and factory lubricated. Nylon is not allowed.

Q. Plug and seal empty spare ducts entering buildings and structures. Install pulling tape in all empty spare ducts. Seal watertight all ducts in use entering buildings and structures in accordance with the specifications.

++ END OF SECTION ++

SECTION 26 05 45

MANHOLES AND HANDHOLES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install manholes and handholes.

B. Coordination:
   1. Coordinate manhole and handhole installation with piping, sheeting and other underground systems and structures and locate clear of interferences.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified:
   1. National Electrical Code (NEC) current adoption.
   2. Materials shall be UL listed where applicable.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's technical information for manholes, handholes and accessories proposed for use.
   2. Drawings showing interior and exterior dimensions and details of openings, jointing, inserts and reinforcing.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Material and Construction:
   1. Precast or cast-in-place type of reinforced concrete. Composite manholes and covers for handholes smaller the 4 feet in any dimension may be acceptable if approved by the owner. Composite manhole shall be single-piece, factory integrated, light weight, and corrosion resistant.
   2. Minimum interior dimensions as shown on the Drawings.
   3. Duct entrances sized and located to suit duct banks.
   4. Handholes and Manholes must have a bottom.

B. Accessories:
   1. Frames and Covers:
      a. Material: Cast iron conforming to ASTM A 48, Class 30A.
      b. Covers: Watertight, sealed type marked "ELECTRICAL" in raised 2-inch letters. Identify covers as shown on the Drawings.
         1) Manhole covers to be 36 inches minimum.

c. Frame shall be grouted on the manhole or handhole.
d. Product and Manufacturer: Provide one of the following:
1) Neenah Foundry Company
2) Campbell Foundry Company
3) Or engineer approved equal

2. Pulling Irons:
a. Material: Galvanized steel.
b. Cast in the wall opposite to the centerline of each incoming duct bank and 12 inches below centerline of bottom line of ducts.
c. Product and Manufacturer: Provide one of the following:
1) 8119 by Chance Utility - Hubbell
2) Inwesco Inc
3) Or engineer approved equal

3. Cable Racks:
a. Material: Galvanized steel.
b. Cable racks shall adequately support cables with space allowed for future cables.
c. Each rack shall be a vertical assembly of 24-inch cable racks extending from within 6-inches of the manhole roof slab to within 6 inches of the manhole floor.
d. Product and Manufacturer: Provide one of the following:
1) J-5125 - MacLean Power Systems
2) C203-1125 by Chance Utility – Hubbell
3) Or engineer approved equal

4. Cable Hooks:
a. Material: Galvanized steel.
b. Length: 7-1/2-inch minimum.
c. Product and Manufacturer: Provide one of the following:
1) J-5132A – MacLean Power Systems
2) C203-1132 by Chance Utility – Hubbell
3) Or engineer approved equal

5. Insulators:
a. Material: Porcelain.
b. Product and Manufacturer: Provide one of the following:
1) J-5122 – MacLean Power Systems
2) C203-1120 by Chance Utility – Hubbell
3) Or engineer approved equal

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install manholes and handholes where shown on the Drawings. Verify final locations in field. Responsibility belongs to CONTRACTOR for all excavation and backfilling required for installation.

B. Complete installation of manholes and handholes so that structures are watertight. Apply foam sealant to all openings and penetrations. Seal all conduit openings to provide a water/bug-tight seal.
1. Product and Manufacturers:
a. DUX - Duct Sealing Compound – O-Z/Gedney - Emerson

b. Type FST Foam Sealant – American Polywater Corp

C. Cable Supports in Manholes:
   1. Attach cable racks with 3-inch by 3/8-inch diameter "tamp-in" studs mounted in 1-inch holes drilled into walls of manholes in the absence of inserts. Apply PVC coating to all racks.
   2. Provide cable hooks to support each cable on each rack along the cable run within the manholes. Apply PVC coating to all hooks.
   3. Individually support each cable at each hook on porcelain insulators. Provide sufficient slack for each cable.
   4. Securely tie each cable in place at each insulator block to prevent excessive movement of insulators, cables, or fireproof tape. Tie cables with non-metallic 3/4-inch strapping tape as manufactured by 3M or tie down with nylon straps.

D. Grounding: Install a 3/4-inch by 10-foot copper-clad ground rod for each manhole. Bond all exposed metal manhole accessories and the concrete reinforcing rods with No. 4 AWG minimum bare copper wire and connect to the ground rod and to the duct bank ground cable.

E. Sump: Provide a 12-inch by 12-inch by 6-inch sump in manhole floor.

F. Provide grading rings for manholes when required to adjust cover to proper grade. Grading ring shall be minimum of 12 inches in height, constructed on the roof slab or cone section on which the manhole frame and cover shall be placed. The height of the grading ring shall be such as is necessary to bring the frame to the proper grade.

G. Metal Pullbox: only where explicitly shown on the drawings install NEMA 4X stainless steel wall mounted pullbox inside manholes/handholes where analog signal cables are mixed with power cables. Route conduits for analog cables directly into and out of metal pullbox so that no analog cables are exposed.

++ END OF SECTION ++

SECTION 26 05 53

ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 SUMMARY

A. Provide identification nameplates and labels in accordance with this Section and the drawings for the following:
   1. Identification for raceway and metal-clad cable.
   2. Identification for conductors and communication and control cable.
   3. Underground-line warning tape.
   4. Warning labels and signs.
   5. Instruction signs.
   6. Equipment identification labels.
   7. Miscellaneous identification products.

1.2 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

1.3 QUALITY ASSURANCE

A. Comply with ANSI A13.1 and ANSI C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.145.

PART 2 - PRODUCTS

2.1 RACEWAY AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Color for Printed Legend:
   1. Power Circuits: Black letters on an orange field.
   2. Legend: Indicate system or service and voltage, if applicable.

C. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

D. Conduits and cables shall be identified as indicated on the drawings.

2.2 CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS

A. Marker tags: heat shrink wire tags, with circuit identification legend machine printed by thermal transfer or equivalent process.

2.3 UNDERGROUND-LINE WARNING TAPE

A. Description: Permanent, bright-colored, continuous-printed, polyethylene tape.
   1. Not less than 6 inches wide by 4 mils thick.
   2. Compounded for permanent direct-burial service.
   3. Embedded continuous metallic strip or core with red polyethylene film on top and with clear polyethylene film on the bottom.
   4. Printed legend shall indicate type of underground line and "CAUTION BURIED ELECTRIC LINE BELOW".

B. Product and Manufacturer: Provide one of the following:
   1. Identoline, "Buried Underground Tape" – Brady Coporation
   2. Thomas & Betts
   3. Or engineer approved equal

2.4 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive 2-sided adhesive tape, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.

C. Letters shall be 3/4 inch. Font shall be capitalized block characters. White letters on black.

D. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4-inch grommets in corners for mounting. Nominal size, 7 by 10 inches.

E. Metal-Backed, Butyrate Warning Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for application. 1/4-inch grommets in corners for mounting. Nominal size, 10 by 14 inches.

F. Warning label and sign shall include, but are not limited to, the following legends:
   1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
   2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES "

2.5 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. in. and 1/8 inch thick for larger sizes.

B. Letters shall be 3/4 inch. Font shall be capitalized block characters. White letters on black.

C. Punched or drilled for mechanical fasteners.

D. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.6 EQUIPMENT IDENTIFICATION LABELS

A. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a black. Minimum letter height shall be 3/4 inch. Font shall be capitalized block characters.

2.7 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.
   1. Minimum Width: 3/16 inch.
   2. Tensile Strength: 50 lb minimum.
   3. Temperature Range: In accordance with the specifications.
   4. Color: Black, except where used for color-coding.

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 APPLICATION

1.

B. Accessible Raceways and Metal-Clad Cables More Than 600 V: Identify with "DANGER-HIGH VOLTAGE" in black letters at least 2 inches high, with self-adhesive vinyl labels. Repeat legend at 10-foot maximum intervals.

C. Power-Circuit Conductor Identification: For primary and secondary conductors No.1/0 AWG and larger in vaults, pull and junction boxes, manholes, and handholes use color-coding conductor tape. Identify source and circuit number of each set of conductors. For single conductor cables, identify phase in addition to the above.

D. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.
   1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.

E. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable. Install underground-line warning tape for both direct-buried cables and cables in raceway. Install warning ribbon approximately 12 inches below finished grade and centered on direct buried cables, electrical ductbanks and conduits without ductbank encasement.

F. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply self-adhesive warning labels. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.
1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to, the following:
   a. Power transfer switches.
   b. Controls with external control power connections.
2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.

G. Instruction Signs:
1. Operating Instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

H. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
1. Labeling Instructions:
   a. Indoor Equipment: Self-adhesive, Engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1 1/2-inch high label; where 2 lines of text are required, use labels 2 inches high.
   b. Outdoor Equipment: Engraved, laminated acrylic or melamine label 4 inches high.
   c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
2. Equipment to Be Labeled:
   a. Panelboards, electrical cabinets, and enclosures.
   b. Access doors and panels for concealed electrical items.
   c. Electrical switchgear and switchboards.
   d. Transformers.
   e. Electrical substations.

f. Emergency system boxes and enclosures.
g. Motor-control centers.
h. Disconnect switches.
i. Enclosed circuit breakers.
j. Motor starters.
k. Push-button stations.
l. Power transfer equipment.
m. Contactors.
n. Remote-controlled switches, dimmer modules, and control devices.
o. Battery inverter units.
p. Battery racks.
q. Power-generating units.
r. Voice and data cable terminal equipment.
s. Monitoring and control equipment.
t. Uninterruptible power supply equipment.

3.2 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach non-adhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.

F. System Identification Color Banding for Raceways and Cables: Each color band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

G. Color-Coding for Phase Identification, 600 V and Less: Use the colors listed below for ungrounded service, feeder, and branch-circuit conductors.
   1. Colors for 208/120 V Circuits:
      a. Phase A: Black.
      b. Phase B: Red.
      c. Phase C: Blue.
   2. Colors for 480/277 V Circuits:
      a. Phase A: Brown.
      b. Phase B: Orange.
      c. Phase C: Yellow.
   3. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps

are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

H. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

I. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

3.3 EQUIPMENT IDENTIFICATION

A. Provide identification of each electrical item, in addition to the manufacturer's nameplates, to identify the item's function, and the equipment or system which it serves or controls.

B. Identify equipment by means of nameplates. Re-label existing equipment whose designation has been changed.

C. Identify pull and terminal boxes with nameplates. Identify each box by a unique number. Numbering system shall reflect the actual designations used in the field and as documented on wiring diagrams.

D. Process/Mechanical/Electrical equipment located outdoors shall be labeled by the manufacturer: "For Outdoor Use".

E. Equipment Voltage Labels:
   1. Voltage labels shall be installed on all equipment that has voltage in the equipment.
   2. Where applicable, install voltage label below the Arc Flash Warning label.
   3. If the equipment has access to the backs or side of the gear, apply voltage labels on all access panels.
   4. Provide standard 3 1/2-inch by 5-inch, Black/Red on White rectangular labels to match Figure 3.1.A below.
   5. Apply a "Danger High Voltage" label to all medium equipment greater than 600 V.
   6. Product and Manufacture: Provide the following:
      a. BRADY
         1) DANGER 120 VOLTS, Part # 86784
         2) DANGER 208 VOLTS, Part # 86782
         3) DANGER 240 VOLTS, Part # 86785
         4) DANGER 480 VOLTS, Part # 86783
         5) DANGER HIGH VOLTAGE INSIDE, Part # 86861
      b. Or Equal

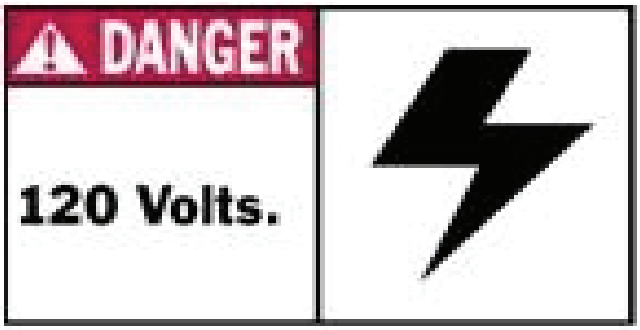

Figure 3-1. A

F. Service Entrance Sections:
   1. Install a Danger Electrical Hazard & Voltage placard on the front side of all Service Entrance Sections.
      a. Placard to be Black/Red on White on aluminum and size to be 7-inch by 10inch to match Figure 3.2.B below.
      b. Install 1 3/4-inch x 3 1/2-inch, type printed, high performance polyester appropriate voltage level labels on the placard. Hand written is not allowed
   2. If the Service Entrance Section has access to the backs or side of the gear, apply voltage labels per Paragraph 2.2.C above and Arc Flash Potential Warning labels per Paragraph 2.2.B.2 on all access panels at each main breaker.
   3. Product and Manufacture: Provide the following:
      a. BRADY
         1) DANGER _____ VOLTS, Part # 43141
      b. Or Equal

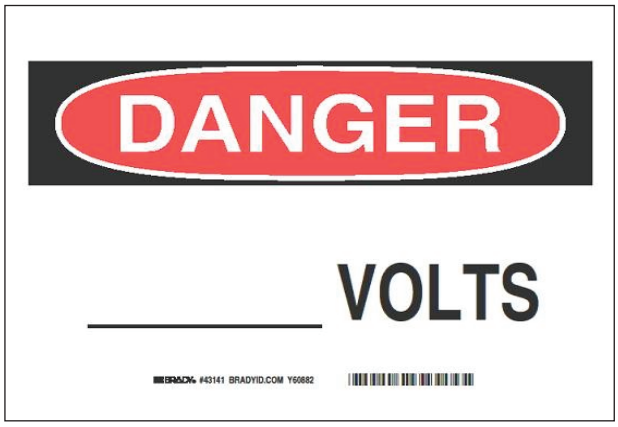

Figure 3-2. B

G. Utility Sections:

1. When the Utility Sections has access to the back, apply a standard 3 1/2-inch by 5-inch, Black/Red on White rectangular "Danger" label stating to match Figure 3.3.C below and Arc Flash Potential Warning labels.
2. Product and Manufacture: Provide the following:
   a. BRADY
   b. Or Equal

Figure 3-3. C

H. Additional Sources of Power:
1. When more than one source of power is located inside the equipment apply standard 3 1/3-inch by 5-inch, Black/Red on White rectangular "Danger" label stating to match Figure 3.4.D below.
2. Product and Manufacture: Provide the following:
   a. BRADY
   b. Or Equal

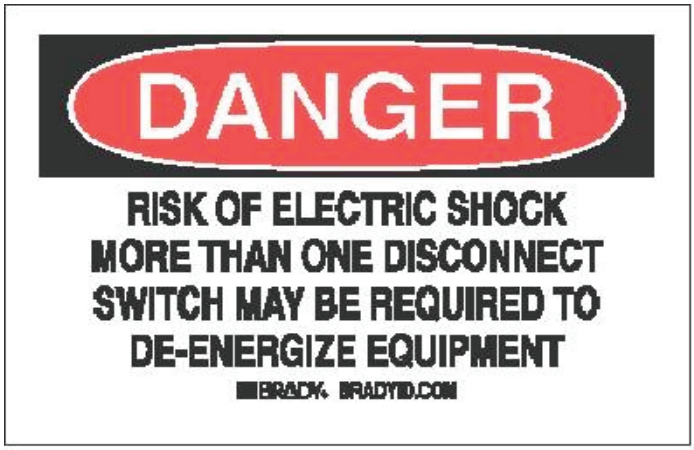

Figure 3-4. D

I. Generator Power Sources:
   1. There are to be no Arc Flash Potential Labels printed or applied pertaining to any system that has generation power as an alternate source. For these sites apply at the automatic transfer switch a standard 3 1/2-inch by 5-inch, Black on Orange "WARNING" label stating to match Figure 3.5.E below
   2. Product and Manufacture: Provide the following:
      a. BRADY
      b. Or Equal

Figure 3-5. E

++ END OF SECTION ++

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SECTION 26 05 73

POWER SYSTEM STUDIES

PART 1 - GENERAL

1.1 DESCRIPTION

A. General:
   1. The CONTRACTOR shall Obtain and pay for the services of an electrical distribution equipment manufacturer or engineering firm, subject to the approval of the ENGINEER, here-in be referred to as ANALYSIS FIRM, to perform the POWER SYSTEM / ARC FLASH ANALYSIS.
   2. The Power System / Arc Flash Analysis shall consist of a preliminary and final Power System Short Circuit Study, Protective Device Coordination Study, load flow study, Device Evaluation, Harmonic Study, Motor Starting Study, voltage drop calculation, power factor calculation, and Arc Flash Analysis for the entire Electrical Distribution System (EDS) as specified in the CONTRACT DOCUMENTS.
   3. The software used to conduct the study and analysis shall be the latest version of SKM Power Tools, EDSA, ETAP, or approved equal

1.2 SCOPE

A. CONTRACTOR Information for Analysis:
   1. The CONTRACTOR shall be responsible for providing the following data to the ANALYSIS FIRM:
      a. Project Schedule.
      b. Electrical Utility contact information.
      c. Division 26, Electrical, ENGINEER approved submittals, including the ENGINEER'S review comments.
      d. Additional equipment information as requested by the ANALYSIS FIRM per Section 1.2.A3.
      e. Marked up single line diagram(s) with installed conductor lengths, sizes and count.
      f. Changes in design as a result of RFI's, Addendums, ENGINEER Clarifications, Sketches or revisions, which may affect the Power System / Arc Flash Analysis.
   2. Based upon outcome of analysis additional equipment information may be required by the CONTRACTOR for upstream or downstream equipment in the electrical distribution system.
   3. CONTRACTOR shall be responsible for implementation of the protective device settings. Implementation of recommended settings outside of the project scope of work resulting from system coordination changes is the responsibility of the OWNER.
   4. CONTRACTOR shall provide ANALYSIS FIRM with safe access to all equipment on site throughout construction for the purpose of verifying the EDS protective device information.
   5. CONTRACTOR shall install labeling as required by the specifications for voltage labeling and other labels as required.

B. Analysis firm shall conduct a Power System/Arc Flash Analysis for new and modified areas of the EDS as specified in the CONTRACT DOCUMENTS. The analysis shall be

performed in accordance with IEEE and shall utilize the ANSI method of short circuit analysis. A model of the EDS shall be developed or modified using ENGINEER'S approved Equipment Submittals, site collected data, and Utility short circuit data. Deliverables shall include short circuit analysis results, protective device coordination analysis results, load flow study, Device Evaluation, Harmonic Study, Motor Starting Study, voltage drop calculation, power factor calculation, and arc flash / shock hazard analysis results and work tasks required by the CONTRACTOR. The ANALYSIS FIRM shall coordinate new protective devices with existing protective devices in the EDS as required.

C. Where additional electrical equipment is being added or modified and upon request from the ANALYSIS FIRM, the ENGINEER will transmit the existing Arc Flash Documentation to the ANALYSIS FIRM for use in completing the required updates.

D. ANALYSIS FIRM shall acquire the Electrical Utility Company's published available Short Circuit current tables for use in the studies. For larger service sizes greater than 480VAC, the ANALYSIS FIRM is to coordinate with the ENGINEER and Utility Company for calculated available short circuit current.

E. ANALYSIS firm shall verify that protective devices are correct per model and analysis results.

F. ANALYSIS FIRM shall install arc flash labels per this specification.

G. ANALYSIS FIRM shall install the updated laminated Single Line Diagram's, Panel Schedules, and Load Summaries. Updates will be made by the ANALYSIS FIRM based on as-build documentation provided by the CONTRACTOR.

A. Power System/Arc Flash Analysis shall consist of a complete fault current, device evaluation, protective devices selective coordination, harmonic study, motor starting study, load flow study, voltage drop calculation, power factor calculation, and Arc Flash Analysis. The study shall begin with the utility company's feeder protective device and include all of the electrical protective devices down to and including the largest feeder circuit breaker and motor starter in the all low voltage motor control centers and power distribution panelboards. The study shall also include variable frequency drives, harmonic filters, Uninterruptible Power Supplies (UPS), power factor correction equipment, transformers and protective devices associated with emergency and standby generators, and the associated paralleling equipment and distribution switchgear. The arc flash study shall begin with the utility company's feeder protective device and include all of the electrical distribution equipment down to and including low voltage motor control centers and power distribution panelboards and lighting panels. The CONTRACTOR shall be responsible for all information required to perform the study.

B. Submit the preliminary short circuit, selective coordination and motor starting/running study prior to submittal of medium voltage switchgear, 480 Volt switchboard, motor control centers, transformers, and 480 Volt and 120 Volt panelboards shop drawings. The aforementioned shop drawings will not be reviewed until the preliminary power system study is approved by the ENGINEER. No exceptions will be allowed. The preliminary study shall include but not limited to:
   1. Obtain and verify with the utility company all information needed to conduct the study. Obtain and verify with the OWNER ratings of existing electrical equipment that shall be included in the study.

2. Current transformers' ratio and burden calculations shall be based on a 10 percent maximum ratio error per ANSI C57.13. Identify current transformers that will not allow the protective devices to operate within acceptable ANSI error margins and recommend corrective action.
3. The preliminary study shall verify equipment is being applied within their design ratings and electrical protective devices will coordinate.
4. Recommend changes and/or additions to equipment as required providing adequate protection and coordination based on the actual equipment supplied and the results of the short circuit and protective device selective coordination studies. Submit any such changes and additions as a part of the study. Field settings of devices, adjustments, and minor modifications to equipment that are required to accomplish conformance with the approved short circuit and protective device selective coordination studies shall be carried out by the CONTRACTOR at no additional cost to the OWNER.

C. After release of electrical equipment by the manufacturer, but prior to energizing the electrical equipment, submit the final short circuit and selective coordination study including all calculations, tabulations, protective devices coordination graphs, etc. as specified herein.
   1. Provide a complete short circuit study and protective device selective coordination study for both the utility power distribution system and the emergency/standby power distribution system under the scope of this study. The study shall include but shall not be limited to:
      a. Full compliance with applicable ANSI and IEEE Standards.
      b. Preformed on nationally recognized computer software such as EDSA, SKM System Analysis, ETAP, or equal.
   2. Recommend changes and/or additions to equipment as required providing adequate protection and coordination based on the actual equipment supplied and the results of the short circuit and protective device selective coordination studies. Submit any such changes and additions as a part of the study. Field settings of devices, adjustments and minor modifications to equipment that are required to accomplish conformance with the approved short circuit and protective device selective coordination studies shall be carried out by the CONTRACTOR at no additional cost to the OWNER.

1.3 REFERENCES

A. Reference Standards: Comply with applicable provisions and recommendations of the latest edition of the following, except where otherwise shown or specified.
   1. IEEE 141, Recommended Practice for Electric Power Distribution for Industrial Plants.
   2. IEEE 241, Recommended Practice for Electrical Power Systems in Commercial Buildings.
   3. IEEE 242, Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.
   4. IEEE 399, Recommended Practice for Industrial and Commercial Power System Analysis.
   5. IEEE 519- Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.
   6. IEEE 1584, Guide for Performing Arc Flash Hazard Calculations.
   7. NFPA 70E, Standard for Electrical Safety in the Workplace.
   8. ANSI C37.010, Method of Short Circuit Analysis.

9. Standard C37.90, IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus.
10. Standard C37.91, IEEE Guide for Protective Relay Applications to Power Transformers.
11. Standard C37.95, IEEE Guide for Protective Relaying of Utility-Consumer Interconnections.
12. Standard C37.96, IEEE Guide for AC Motor Protection.
13. Standard C57.12.59, IEEE Guide for Dry-Type Transformer Through-Fault Current Duration.
14. Standard C57.13, IEEE Standard Requirements for Instrumentation Transformers.
15. Standard C57.109, IEEE Guide for Liquid-Immersed Transformer Through-Fault-Current Duration.
16. NFPA 70, National Electrical Code (NEC).

1.4 SUBMITTALS

A. Preliminary Technical Memorandum:
   1. ANALYSIS FIRM shall provide a preliminary submittal for review and a technical memorandum in accordance with the study requirements in this specification. This will be submitted for approval by the ENGINEER and OWNER. Submittal shall include:
      a. Technical Memorandum
         1) Review for adequate installation based on available fault current
         2) Recommendations for alternate equipment based on system coordination
         3) Recommendations for alternate design considerations based on energy levels
         4) Report shall include:
            a) Input Data
            b) Result tables for each study, including each scenario for utility power, standby power, etc.
            c) Graphic, color, time-current curves
            d) One-Line diagram
            e) CT ration and burden calculations to show that they will not saturate under any fault condition.
   2. Preliminary Technical Memorandum shall be submitted and reviewed by the ENGINEER to ensure EDS electrical equipment order being released for manufacturing meets the requirements of the project.

B. Final Report:
   1. ANALYSIS FIRM shall submit a final sealed report upon project substantial completion in accordance with the study requirements in this specification. Final report shall be in PDF format and include all documents as noted below.
   2. ANALYSIS FIRM to provide the following documents in the final report:
      a. Final Report with explanatory text specific to the project.
      b. All input and calculated data in tabular form.
      c. Description of all scenarios studied.
      d. Conclusions and recommendations.
      e. Overcurrent protective device and relay settings tables.
      f. Annotated Single Line Diagrams – Power Study Management Scenario with available fault currents and voltage drop shown.
      g. Time Current Curves.
      h. Arc Flash Labels.

C. Final Short Circuit and Selective Coordination Study Report shall include but not limited to:
   1. The selection of all protective relay types, current transformers, fuse types and ratings shall be the responsibility of the manufacturer and shall be based on the preliminary coordination study, which shall be submitted prior to the equipment shop drawings. The complete study shall be approved by the ENGINEER before any equipment is shipped. The report shall include the following sections and information:
   2. A technical memorandum Summary outlining the distribution system, the information received from the power company, assumptions made to complete the report, statement of the adequacy of the distribution equipment to safely clear any fault currents, the adequacy of the distribution equipment to close in on a fault, identify any problem areas with provide recommendations for resolving the problem.
   3. Electrical distribution system one-line diagram. One-line diagrams shall be legible on printed paper and shall not exceed 11 x 17 inches in size. Provide multiple pages if necessary.
   4. Provide detailed "Input Data" report that identifies all input parameters associated with the equipment depicted on the system one line diagrams including but not limited to Utility data, conductor sizes and lengths, protective device sizes and rating, transformer sizes and ratings, motor types and sizes, etc.
   5. Tabulation of all protective devices, circuit breakers, fuses, current transformers, etc. The tabulation shall indicate the device, manufacturer, catalog number, recommended setting, etc.
   6. Provide current transformers' ratio and burden calculations to confirm that the current transformers will not saturate prior to operation of the protective relays and to confirm the current transformers used with differential protection will not saturate under any fault condition.
   7. Transformer differential protection calculations including current transformer mismatch relay setting and charts. Provide differential current transformer wiring schematics including polarity and wiring connections based on the winding configuration of the actual power transformers being supplied.
   8. Graphic time current, protective relay and protective device curves, showing equipment and material damage curves, relay, circuit breaker, fuse curves, available fault currents at the equipment, transformer inrush currents, etc., for each piece of equipment. TCC's shall be produced and printed in color to assist the reviewing ENGINEER in the graphical analysis of the protective device coordination. Each device on a TCC shall be a different color and where devices are shown on multiple TCCs the color for the device shall be constant on each TCC that the devices are shown on.
   9. Tabulation of each protective device, its short circuit rating, the available fault current available at the device, and PASS/FAIL indication whether or not the device is adequately rated for the available fault current and voltage at which it is applied.

D. Preliminary Arc Flash Study Report shall include but not limited to:
   1. A technical memorandum Summary outlining the distribution system, the information received from the power company, assumptions made to complete the report and recommendations to reduce the arc flash values.
   2. Recommendations to reduce the arc flash incident energy levels

E. The Final Arc Flash Study report shall include the following sections and information:

1. A summary outlining the distribution system, the information received from the power company, assumptions made to complete the report and recommendations to reduce the arc flash values.
2. Provide a detailed bus label for each fault location. Each label shall include a listing of the protective device settings and incident energy at several different working distances.
3. Provide A NFPA 70 E work permit form for each fault location.
4. Provide labels for each fault location.
5. PPE Table – Provide a PPE table that defines the Personnel Protective Equipment and clothing descriptions identified in the reports and labels for each incident energy range.

F. Preliminary Harmonic Study Report shall include but not limited to:
   1. Electrical distribution system one-line diagram.
   2. Provide the minimum available fault current available from the utility and show the calculations of plant load vs. available fault current to determine the appropriate THD threshold as defined in IEEE 519.
   3. Provide the harmonic parameters assumed for use in the study for the harmonic generating equipment, i.e., VFD units, UPS units, static inverters, Ozone units, etc.

G. Final Harmonic Study Report shall include but not limited to:
   1. The selection of the harmonic mitigation equipment shall be the responsibility of the manufacturer and shall be based on the preliminary harmonic study, which shall be submitted prior to the equipment shop drawings. The complete study shall be approved by the ENGINEER before any equipment is shipped. The report shall include the following sections and information:
      a. A summary outlining the distribution system, the information received from the power company, assumptions made to complete the report, document harmonic profile for all harmonic producing equipment.
      b. Electrical distribution system one-line diagram.
      c. Recommended parameters for harmonic mitigation equipment, if required. Recommendations shall detail the projected effects of the mitigation effects and shall prove them via a revised harmonic study.
      d. Calculations and documentation indicated.

1.5 QUALITY ASSURANCE

A. Analysis Firm's Experience
   1. Specialty firm shall have been in the business of the type of work specified, for at least the past five years.
   2. The specialty firm shall have a minimum of three projects of equal or greater size, service, with the type of equipment specified for each of the past three years.

B. All electrical studies shall be stamped and signed by a professional electrical engineer. The ENGINEER shall be registered in the State in which the equipment will finally reside.

PART 2 - PRODUCTS

2.1 POWER SYSTEM / ARC FLASH ANALYSIS FINAL REPORT

A. Professional Certified Report:

1. ANALYSIS FIRM shall provide a certified report that shall include but is not limited to:
    a. An executive summary.
    b. Methods, assumptions, and procedures used in the analysis.
    c. Findings and recommendations requiring actions not within the ANALYSIS FIRM scope of work.
    d. Electrical Distribution System Overview as illustrated on the CONTRACT DOCUMENTS.
    e. Appendices with the SKM documents of the equipment data used in the analysis and the analysis results.
2. Report shall be reviewed and sealed by a professional engineer registered in the state of Utah

B. SKM Single-Line Diagram(s):
1. SKM Single-Line Diagram(s) legible on 11 x 17-inch sheet size, landscape view. Include the following information:
    a. Location and function of each protective device in the system, such as relays, direct-acting trips, fuses, etc.
    b. Type designation, current rating, range or adjustment, manufacturer's style or type for all protective devices.
    c. Power, voltage ratings, impedance, primary and secondary connections of all transformers.
    d. Type, manufacturer, and ratio of all current transformers energizing each relay.
    e. Manufacturer’s nameplate data of all motors and generators.
    f. Sources of short circuit currents such as utility ties, generators, synchronous motors, and induction motors.
    g. All significant circuit elements such as transformers, cables, breakers, fuses, reactors, etc.
    h. Normal switching conditions where possible.
    i. The final settings of adjustable breakers, relays and direct-acting trips.

C. Short Circuit Study:
1. The short circuit analysis shall be performed in accordance with ANSI Standards C37.010 and C37.13 to determine the adequacy of circuit breakers, surge arresters, busways, switches, and fuses by tabulating and comparing the short circuit ratings of these devices with the available fault currents. Short circuit momentary duties and interrupting duties shall be calculated on the basis of worst case scenario / maximum available fault current at the switchgear busses and motor control centers.
2. Normal system operating method, alternate operation, and operations which could result in maximum fault conditions shall be thoroughly addressed in the analysis. The analysis shall assume all motors operating at rated voltage. Redundant/standby motors shall be excluded where known system limitations prevent simultaneous operation. Electrical equipment bus impedance shall be assumed zero (SKM default setting).
3. The study shall address the case when the system is being powered from the utility source as well as from the on-site generating facilities, normal and alternate (bus tie closed) modes of operation. Minimum and maximum possible fault conditions shall be covered in the study. It shall be the responsibility of the CONTRACTOR performing the study to determine the operating parameters of the system and to derive the worst-case fault conditions.

4. Consider the fault contribution of all motors operating during the maximum demand condition of the motors.
5. Calculate short-circuit momentary duties and interrupting duties on the basis of an assumed bolted 3 phase short circuit at each high and medium voltage switchgear bus and controller, low voltage switchgear bus, switchboard, motor control center, distribution panelboard, pertinent branch circuit panelboard and other significant locations throughout the systems. The short circuit tabulations shall include X/R ratios, asymmetry factors, KVA and symmetrical fault-current. Provide a ground fault current study for the same system areas. Include in tabulations fault impedance, X/R ratios, asymmetry factors, motor contribution, short circuit KVA, and symmetrical and asymmetrical fault-currents.
6. Provide the following:
    a. The available fault current at each bus within the limits of the study shall be identified and listed.
    b. The momentary and interrupting rating of all elements of the distribution system shall be listed. The maximum available fault current available at each element shall be calculated
    c. Determine the adequacy of the electrical protective devices to withstand the maximum available fault at the terminals of the equipment. Provide an equipment list, the equipment rating (both momentary and withstand), the maximum available fault rating and the adequacy of the equipment to withstand the fault. The results shall be tabulated in the form of a PASS/FAIL device evaluation table Equipment that does not have adequate ratings shall be identified immediately and brought to the attention of the ENGINEER.
    d. The short circuit portion of the report shall include:
        1) Summary describing the distribution system, the procedures used to develop the study, utility related information furnished by the utility company including the name and telephone number of the individual supplying the information, identify all assumptions made in the preparation of the study, identify any problem areas and provide a definitive statement concerning the adequacy of the distribution system to interrupt and withstand the maximum possible fault current.
        2) Input data.
        3) Three phase and ground fault studies. Indicate the fault current available at each major equipment, distribution bus within the high, medium and low voltage distribution systems.
        4) Table listing all the electrical distribution and utilization equipment (including VFDs), the equipment interrupting and withstand ratings, the available fault current at the terminals of the equipment and the ability of the equipment to interrupt and/or withstand the fault.
        5) The short circuit study shall be prepared using approved computer software and must include complete fault calculations as specified herein for each proposed and ultimate source combination. Source combinations may include present and future Power Company supply circuits, large motors, or generators.
7. Automatic Load Transfer
    a. Provide a detailed study demonstrating the interrupting capacity of automatic transfer bus ties and switches, as well as the fault withstand capabilities. The following shall be considered:
        1) X/R ratio fault-current of circuit at point of transfer.
        2) X/R ratio and fault-current rating of the transfer device.
        3) Length of time fault may persist prior to protective device opening.

4) Magnetic stress withstand rating.
5) I2t withstand rating.
6) Transfer device maximum interrupting duty compared to load interrupting duty.

D. Protective Device Coordination Study:
1. The protective device coordination analysis shall be performed in accordance with ANSI/IEEE Std. 242 to determine the required settings/sizes of the protective devices to maximize selectivity. The phase over-current and ground-fault protection settings shall be included as well as settings for all other adjustable protective devices, excluding vendor supplied packaged equipment. Areas lacking complete coordination shall be identified and justification provided for allowing condition to remain or the ENGINEER shall provide solution to resolve situation.
2. SKM Time-Current Curve(s) legible on 11 x 17-inch sheet size, landscape view on 10- cycle, green log-log graph paper. Include the following information for each time-current curve:
   a. Protective device, relay, or fuse showing graphically that the settings provide protection and selectivity within industry standards. Each curve shall be identified, and the tap and time dial settings shall be specified.
   b. Each device shall be positioned to provide maximum selectivity to minimize system disturbances during fault clearing. Where selectivity cannot be achieved, the ENGINEER shall be notified as to the cause.
   c. Points for cable and equipment damage.
   d. Circuit interrupting device operating and interrupting times based on the amperage.
   e. A SKM Single line sketch of bus and breaker arrangement for each time-current curve.
3. Provide breaker setting table with sign off form for CONTRACTOR'S use during implementation of breaker settings.
4. Provide coordination plots of protective devices plus tabulated data, including ratings and settings selected. In the study, balance shall be achieved between the competing objectives of protection and continuity of service for the system specified, taking into account the basic factors of sensitivity, selectivity and speed.
5. Provide separate plots for each mode of operation: (1) "double-ended mode" (double-ended substation with bus tie open); (2) "singled ended mode" (single incoming utility feeder energized all switchgears single ended with bus ties closed); (3) "stand-by mode" (on-site generation solely providing power to the system; (4) "peak shaving modes" (a.) (double-ended substation with bus tie open with on-site generation paralleled) and (b) (single-ended with bus ties closed with on-site generation paralleled). Show maximum and minimum fault values in each case. Multiple power sources shown in one plot is not acceptable.
6. Each primary protective device required for a delta-to-wye-connected transformer shall be selected so the characteristic or operating band is within the transformer parameters, which, where feasible, shall include a parameter equivalent to 58 percent of the ANSI C37.91 withstand curve to afford protection for secondary line-to-ground faults. Separate low voltage power circuit breakers from each other and the associated primary protective device, by a 16 percent current margin for coordination and protection in the event of line-to-line faults. Separate the protective relays by a 0.3-second time margin for the maximum 3 phase fault conditions to assure proper selectivity. The protective device characteristics or operating bands shall be terminated to reflect the actual symmetrical and asymmetrical fault-currents sensed by the device. Provide the coordination plots for

3 phase and phase-to-ground faults on a system basis. Include at least all devices down to largest branch circuit and largest feeder circuit breaker in-each motor control center and/or power distribution panelboard. Include all adjustable setting ground fault protective devices.

7. Select relay types (i.e., inverse, very inverse, extremely inverse, over current with or without voltage restraint, timers, etc.), current transformer ratings and types, fuse, residually or zero sequence connected ground faults protection, etc., that will allow the system to be protected to within the equipment fault ratings and provide the maximum possible coordination between the protective devices.
8. Multifunction Solid State Relays
    a. Where multifunction solid state relays are already installed, it shall be the responsibility of the CONTRACTOR to obtain the current and complete list of software setpoints programmed into the device. These setpoints shall be evaluated for potential impacts on the protective device coordination.
    b. Where multifunction solid state relays are being install, it shall be the responsibility of the CONTRACTOR to provide all setpoints needed for the specified operation of the relay. These settings include but are not limited to:
        1) The complete pickup settings of all protective elements specified by the designer and shall not be limited to only the overcurrent pickup settings. Settings for protective elements such as reverse power, synchronization, frequency and voltage control, etc. shall be provided in full.
        2) Differential pickup and zone settings necessary for the relay to operate as specified and designed and to protect the zone it is intended for. Zone of protection calculations and balance equations shall be completed entirely by the CONTRACTOR based on the equipment as furnished and designed.
        3) The complete protective relay logic map and logic equations. The relay logic is responsible for translating the pickups of the protective elements into relay output events and device trips. All logic necessary to create the specified output of the relay based on the specified protective elements shall be furnished with the protective device coordination report.
        4) Any and all miscellaneous settings necessary for the relay to communicate with the installation systems and the mirroring of data to other installation systems as specified or designed.
    c. CONTRACTOR shall be responsible for the programming of relays prior to the field testing and start up requirements of this contract. The CONTRACTOR shall be responsible for all time needed to complete the relay settings in order to furnish a completely functional system as specified and required by the approved protection device settings.
9. Arc Flash Mitigation and Reduction Modes
    a. Where devices are furnished with alternative trip settings intended to mitigate arc flash hazards, the CONTRACTOR shall coordinate these alternative pickup settings and provide representation of their tripping characteristics via TCC’s. The alternative pickup settings shall be coordinate with the associated load and shall be set to provide the fastest device response time while avoiding nuisance trips during normal plant operation.
10. Generator Protective Devices
    a. The study shall address all of the protective devices provided for generator protection.
    b. Protective relays requiring settings shall be included.
    c. The Electrical Contractor shall obtain all necessary generator information to perform this study.
11. Motor Protection and Coordination

a. Provide a complete and independent set of current-time characteristic curves for all motors 50 HP and above indicating coordination between the protective relays and the thermal and starting characteristics of the motor.
b. The CONTRACTOR shall obtain from the motor supplier the necessary information to perform the study. Certified curves for "Safe Time vs. Current at 100% Voltage" and "Accelerating Time vs. Current at 100% Voltage" are necessary and shall become part of the final report.

12. Call discrepancies to the attention of the ENGINEER in the conclusions and recommendations of the report.
13. The Time current Characteristic Curves shall include:
    a. The coordination plots shall graphically indicate the coordination proposed for the several systems centered on full-scale log forms. The coordination plots shall include complete titles, representative one-line diagrams and legends, associated upstream power system relays, fuse or system characteristics, significant motor starting characteristics, significant generator characteristics, complete parameters for power, and substation transformers, complete operating bands for low voltage circuit breaker trip devices, fuses, and the associated system load protective devices. The coordination plots shall define the types of protective devices selected, together with the proposed coil taps, time-dial settings and pick-up settings required. The short-time region shall indicate the relay instantaneous elements, the magnetizing inrush, and ANSI transformer damage curves, the low voltage circuit breaker and instantaneous trip devices, fuse manufacturing tolerance bands, and significant symmetrical and asymmetrical fault-currents.
    b. No more than six devices shall be shown on one coordination plot. Of these six curves, two (the largest upstream device and the smallest downstream device) shall repeat curves shown on other coordination plots in order to provide cross-reference. Give each curve in the study a study-unique number or letter identifier to permit cross-reference between plots.
    c. The coordinating time interval between primary and back-up protective devices shall be as per Table 15-3, Section 15.6, IEEE Std. 242-2001.
    d. Include a detailed description of each protective device identifying its type, function, manufacturer, and time-current characteristics. Tabulate recommended device tap, time dial, pickup, instantaneous, and time delay settings. A tabulation shall include settings for every overcurrent protective device, timer, power system relays (e.g., ANSI 25, 27, 32, 67, 87, etc.), circuit breaker, recommended fuse and current transformer ratings, etc. Include C.T. ratio, burden and all other calculations required for the determination of settings. Provide recommended settings for all protective devices furnished under Division 26, Electrical and furnished with those furnished with Variable Frequency Drives and associated transformers, generators and associated paralleling and distribution switchgear.

E. Arc Flash/Shock Hazard Analysis:
1. The arc flash / shock hazard analysis shall be conducted in accordance with the methods outlined in IEEE Standard 1584 and stated hereinafter. Work shall be in accordance with NFPA 70E which includes the fabrication of labels with the arc flash / shock incident analysis results, OWNER’s personnel protective equipment (PPE) risk level, the energy available, clothing recommendation, equipment name, ANALYSIS FIRM contact information, and date analysis was performed.
2. The analysis shall include the following IEEE 1584 analysis process:
    a. Collect system and installation data.

b. Determine modes of operation.
c. Determine bolted fault current.
d. Determine arc fault current.
e. Determine protective device characteristic and arc fault duration.
f. Document system voltages
g. Select working distances.
h. Calculate incident energy.
i. Calculate the arc flash protection boundary.

3. Provide a copy of each installed Equipment Specific label on 8½ x 11-inch sheet size, portrait view in actual size and color printed and installed on the equipment.
4. Provide an arc flash study that utilizes the fault current values calculated in the short circuit study and the minimum clear times of the upstream protective device selected in the coordination study to calculate the incident energy at each fault location.
5. Calculate the incident energy levels at each faulted bus for each mode of operation: (1) "double-ended mode" (double-ended substation with bus tie open); (2) "singled ended mode" (single incoming utility feeder energized all switchgears single ended with bus ties closed); (3) "stand-by mode" (on-site generation solely providing power to the system; (4) "peak shaving modes" (a.) (double-ended substation with bus tie open with on-site generation paralleled) and (b) (single-ended with bus ties closed with on-site generation paralleled). Determine arc flash incident energy values for both maximum and minimum fault values in each case.
6. Extent of Study
   a. The arc flash study shall include analysis for all equipment that would normally be serviced while energized and cannot be easily shut down during maintenance periods. The CONTRACTOR shall coordinate with the OWNER to ensure that all equipment that is expected to be analyzed is included in the study. The extent of the analysis includes but is not limited to:
      1) Switchgear, MCC's and distribution equipment
      2) Low voltage lighting panels, even those covered by certain calculation exceptions must be modeled and provided with a unique device label
      3) Low voltage control equipment such as 120-600 V control panels.
7. Arc Flash Labels
   a. The arc flash study shall produce a single set of label templates that shall not be printed until the final arc flash study has been approved.
   b. A single set of labels shall be printed and affixed to the equipment analyzed if the equipment is continuous. Double ended equipment shall have individual labels for each side of the gear. Equipment that is not continuous shall have a single label placed on each piece of continuous gear.
   c. Where applicable, LINE and LOAD labels shall be produced for equipment. Examples of equipment that require these labels include the main breakers of switchgear and MCC's. In these cases, the LINE side breakers shall be affixed to indicate the hazard associated with the line side of the equipment and the LOAD label shall be affixed to indicate the hazard associated with the rest of the gear.
   d. Labels shall be affixed where they are clearly identifiable with the equipment they depict. Labels shall not obscure any other signage on the equipment unless they are used to completely cover a previous arc flash label.
   e. Labels shall meet the following requirements:
      1) Labels shall be indoor/outdoor rated weather resistant vinyl or polyester with a UV resistant overlaminate. The label shall have a minimum thickness of 5 mil. Labels shall be backed with pressure sensitive permanent cold

temperature adhesive rated for a minimum 5 year life in the environment in which they are installed.

2) All lettering shall be black and printed via thermal transfer. Backgrounds shall be orange for hazard risk categories 1-4 and red for "Dangerous" areas.
3) Where subjected to degrading or corrosive environments, the labels shall be provided with a tinted fiber glass cover.
4) The label shall match any pre-existing facility or client specified formatting. The CONTRACTOR shall be responsible for obtaining this formatting information prior to submitting label templates.
5) A single label for equipment is acceptable where equipment is continuous. In the event of split busses or equipment not arranged in a continuous fashion, multiple labels shall be provided.
6) Line side labels for equipment main breakers shall be included in addition to load side labels.
7) Labels shall be DANGER/WARNING type conforming to the NFPA 70E and ANSI Z534.4 standards. Labels are required to have the minimum information specified by these standards printed on them. Labels shall be legible and standard throughout the plant.
8) Labels templates shall be provided to the ENGINEER and client for final approval and shall be printed and affixed by the CONTRACTOR. CONTRACTOR shall be responsible for all work required to print and affix the labels to the equipment. Labels shall be affixed in accordance with the direction of the client.

f. CONTRACTOR shall produce all arc flash labels and coordinate affixing them onto all equipment.

8. Arc Flash Mitigation and Reduction Devices
   a. Where devices are furnished with alternative trip settings intended to mitigate arc flash hazards, the CONTRACTOR shall provide an alternative arc flash lookup table associated with these alternative settings.
   b. Labels shall have only the worst case hazard risk category (without the arc flash reduction settings) depicted. Multiple labels for different device settings shall not be accepted.
   c. Devices such as differential protection relays which limit incident energy by limiting the magnitude of the available fault and/or minimizing the fault clearing time may be used to calculate hazard risk categories. The use of these devices in the calculations shall only be permitted where permitted by the standards and code guidelines used to complete the arc flash analysis. If not explicitly stated by the standard as an acceptable method for calculating arc flash hazard, it shall not be permitted.
9. Arc Flash Hazard Mitigation
   a. Acceptable hazard risk categories shall be coordinated by the CONTRACTOR between the OWNER and ENGINEER. Where there are no guidelines determining acceptable arc flash levels, the CONTRACTOR shall actively attempt to reduce all hazard risk categories greater than 2. CONTRACTOR shall list all areas greater that category 2 in the conclusion of the report and shall give reasons for the high incident energy.
   b. The CONTRACTOR shall be responsible for proposing and evaluating arc flash mitigation measure including but not limited to:
      1) Adjustment of protective devices in an attempt to better balance the system coordination and the incident energy available to an arcing fault.
      2) Equipment that could be used to physically remove the operator from the arc flash hazard boundary (mimic panels, remote switching/racking).

3) Equipment that could be used to limit the amount of incident energy or reduce the protective device pickup time (maintenance mode bypass, differential relaying).

c. Proposing an evaluating these arc flash mitigation measures shall include evaluating the cost and implementation of the options as well as reevaluating and reporting the hazard risk category associated with their installation.

F. HARMONIC STUDY

1. Provide a harmonic study for all harmonic producing equipment to determine the harmonic currents and voltages of the electrical distribution system.
2. The harmonic study shall provide a harmonic current and voltage profile for the complete electrical distribution system. At a minimum, the voltage profile shall include voltage values at the utility service point, each switchgear/switchboard and motor control center bus.
3. A complete Harmonic current and voltage profile shall be provided for the minimum anticipated fault current available from the utility and the standby generator for each of the following operating conditions:
   a. All tie circuit breakers open with electrical distribution system operating double-ended.
   b. One profile for all equipment running (Full speed condition for VFD units)
   c. One profile for all equipment running (70% of full speed condition for VFD units).
   d. All tie circuit breakers closed with the electrical distribution system operating single-ended.
      1) One profile for all equipment running (Full speed condition for VFD units)
      2) One profile for all equipment running (70% of full speed condition for VFD units).
4. The CONTRACTOR shall obtain from the harmonic generating equipment suppliers the necessary information to perform the study. Certified harmonic information is absolutely necessary and shall become part of the final report.
5. The harmonic study shall contain, as a minimum, the following:
   a. Explanation of method used to perform the study.
   b. Explanation of study results with specific recommendations on filters and/or other measures that will be implemented to meet the specified limits.
   c. All calculations and/or computer printouts used to arrive at the recommendations.
   d. Individual drive voltage and current harmonic content up to the fiftieth harmonic, and the combined total of all the drive harmonic contents reflected in the system source supply voltage and current as a percent of the 60 Hz fundamental under actual load conditions from 0 to 60 Hz at 10 Hz increments.
6. If the harmonic distortion for voltage and current distortion levels and line notching do not meet the requirements of IEEE 519. The CONTRACTOR shall specify the appropriate filter traps that provide the filtering required to meet the requirements of IEEE 519 as specified herein.
7. The manufacturer shall be responsible to provide all data necessary to perform the study. This includes nonlinear load producing equipment signature, feeder cable sizes, approximate feeder length, motor data, switchgear data, utility data, alternate source data, existing field data (if required) and any other information relevant to the study.

2.2 LABELS

A. Arc Flash Potential Labels:

1. Category Label:
   a. A standard Arc Flash Warning label shall be installed on all equipment with a Category 1 or 2 with available fault current less than 25kAIC. All other components must have an equipment specific label generated from SKM using calculated values as described in 2.2.A.2.
   b. Provide a 2 1/2 x 3 1/2-inch label format with coloring to match one of the labels shown on Figure 2.2.B.1 below.

WARNING
Arc Flash and Shock Hazard
PPE Category Required Per NFPA 70 E Table **Category 1 Minimum Arc Rating of 4 cal/sq. cm** **@ Working Distance of 18 Inches** **120-208/240 VAC w/ Isc <25kA** **Arc Flash Boundary = 19 Inches**

WARNING
Arc Flash and Shock Hazard
PPE Category Required Per NFPA 70 E Table **Category 2 Minimum Arc Rating of 8 cal/sq. cm** **@ Working Distance of 18 Inches** **277/480 VAC w/ Isc <25kA** **Arc Flash Boundary = 36 Inches**

Figure 2.2.B.1

2. Calculated Specific Equipment Labels:
   a. Arc Flash Potential Warning labels shall be installed on all equipment with a calculated energy level.
   b. Provide standard 4 x 5-inch rectangular labels.
   c. Provide a label format with coloring to match Figure 2.2.B.2 below.

WARNING	
Arc Flash and Shock Hazard	
Appropriate PPE Required	
480 VAC	Shock Hazard when cover is removed

94 in	Flash Hazard Boundary
18 cal/cm^2	Flash Hazard at 18 Inches
	Minimum Rating of 25 cal/sq cm
Level 3	**Cotton Underwear + AR Shirt & Pants or AR Arc Flash Suit + AR Flash Hood**
42 Inches	Limited Approach
12 Inches	Restricted Approach
EQUIPMENT:	**SES LOAD SIDE MAIN**
SKM SLD:	001 1 Line-UH-All
Firm:	ABC Electrical
Contact Info:	(123) 456-7890
Date:	01/01/2000
Warning: Changes in equipment setting or system configuration will invalidate the calculated values and PPE requirements	

Figure 2.2.B.2

3. Label Material:
   a. Label shall be an indoor/outdoor high performance, pressure sensitive safety sign.
   b. Materials shall be UV rated surface printed polyester with polyester over-laminate. Labels shall be abrasion, chemical and heat resistant (-40 to 110 degrees C (-40 to 230 degrees F)), with an average outdoor durability of five to eight years.
   c. Product Manufacture: Provide the following:
      1) Printer and Label Materials
         a) BRADY Powermark Printer, BRADY Label Part# 13651
         b) Or Equal

PART 3 - EXECUTION

3.1 GENERAL

A. ANALYSIS FIRM shall inspect all installed equipment for conformance with the fully executed POWER SYSTEM / ARC FLASH ANALYSIS. Any deviations found shall immediately be brought to the OWNER and ENGINEER'S attention.

3.2 BREAKER SETTINGS

A. The CONTRACTOR shall coordinate with the ANALYSIS FIRM to implement the breaker settings defined in the approved preliminary report submittal.

B. The ANALYSIS FIRM shall inspect all breaker settings implemented in the field by the CONTRACTOR. If the recommended breaker setting(s) are adjusted, the ANALYSIS

FIRM will update the final report with the actual settings. CONTRACTOR or ENGINEER is to provide written justification for any deviations.

3.3 BREAKER TESTING

A. The CONTRACTOR shall coordinate the final settings of the breakers during the start-up and functional testing of the process systems EDS. If the breaker settings require adjustment, the CONTRACTOR will coordinate with the ENGINEER and ANALYSIS FIRM to update the Power System Arc Flash Analysis Report with the final settings.

3.4 LABELING

A. All Service Entrance Sections (SES), switchboards, switchgear, Motor Control Centers (MCC), transformers, distribution boards, panel boards, disconnects and control panels shall have both an arc flash label and voltage label. ANALYSIS FIRM shall determine the proper arc flash label.
   1. Install all labels level and in an upright position. Do not cut or alter in any way. Install label in a professional manner. Clean surface as needed to allow for good adhesion.
   2. Labels shall not be installed atop any manufacturer name plate data or equipment tag labels.
   3. Where equipment does not have sufficient space for an Arc Flash Label the CONTRACTOR shall furnish a fabricated mounting plate constructed of stainless steel sheet metal per direction from the ENGINEER. Mounting plate shall be affixed to the equipment using stainless steel screws. Installation shall maintain the equipment NEMA rating of the equipment. Mounting plate shall not interfere with equipment operation and shall be readily visible.
   4. In the case of more than one source of power to a piece of equipment, the highest voltage label shall be applied, and an additional label shall be applied indicating more than one source of power located inside the equipment.
   5. For outdoor switchgear, place a single Arc Flash label on the outside of the access door nearest to the main breaker, and one inside on the respective breaker enclosure. All other Arc Flash labels shall be placed inside the access doors on the respective breaker enclosure or cover. If there are back access panels to the equipment, the arc flash labels placed at the front of the gear shall be duplicated and placed on the back access panels at the same relative location.
   6. For disconnect switches, panel boards, distribution boards, load centers, and control cabinets, the labels should be applied in plain view on the front cover.

++ END OF SECTION ++

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SECTION 26 12 19

PAD-MOUNTED TRANSFORMERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide the labor, materials, equipment, incidentals required to furnish and install pad-mounted transformers 150 KVA and larger with copper windings, complete and operational, as specified and shown on the Drawings.
   2. Transformers shall be coordinated with Provo Power and must meet Provo Power specifications in addition to the specifications below.
   3. Provide anchorage and support design, including seismic, for pad-mounted transformers in accordance with General Electrical Provisions under Division 26.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified.
   1. NEMA TR1, Transformers, Regulators and Reactors.
   2. ANSI C57.12, General Requirements for Distribution, Power, and Regulating Transformers.
   3. ANSI C57.93, Guide for the Installation and Maintenance of Oil-Immersed Transformers.
   4. National Electrical Code (NEC) current adoption.
   5. IEEE, Institute of Electrical and Electronic Engineers.
   6. ASTM, American Society of Testing and Materials.
   7. UL, Underwriter’s Laboratories.

B. Factory test prior to shipment in accordance with ANSI Test Code C57.12.00/C57.12.90. Furnish test results to ENGINEER. Tests shall include:
   1. Polarity check
   2. Ratio check
   3. No-load loss
   4. Exciting current at rated voltage
   5. Load loss
   6. Impedance
   7. Production line impulse test
   8. Dielectric tests at low frequency
   9. Mechanical leak test

C. UL listed and labeled.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's technical information for pad-mounted transformers proposed for use, including pad layout with all dimensions, weight, ratings, and accessories identified.
   2. Support hardware information.

3. Drawings:
    a. Plan and elevation.
    b. Anchoring details.
    c. Bushing details.
    d. Conduit Entrance openings.
    e. Wiring Details
    f. Nameplate.
4. Reports of transformer factory tests.

B. Operation and Maintenance Manual.
1. Instruction, operating and maintenance manual covering all equipment furnished in accordance with the specifications.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Rating:
1. Ratings as indicated on the drawings.
2. Coolant: Mineral Oil.
3. Temperature Rise: 65 degrees C (149 degrees F).
4. Taps: Full capacity, two 2 1/2 percent primary taps above normal and two 2 1/2 percent primary taps below normal.
5. Impedance: 5 3/4 percent.

B. Construction:
1. Dead-front construction.
2. Compartmental-type unit consisting of transformer tank with high and low-voltage cable terminating compartment, assembled as an integral unit for mounting on a pad.
3. Externally clamped high voltage epoxy bushing wells for 200 A load-break, or 600 A non-load-break inserts. Steel barrier separating low-voltage compartment.
4. Low-voltage compartment with bushings and NEMA spade terminals and ground lug. Provide link to solidly ground X0 terminal to ground lug.
5. Tamper proof design with no exposed screws, bolts or other fastening devices which are externally removable and no openings through which foreign objects might contact live parts.
6. Full-height, incoming and outgoing terminal compartments with hinged doors and steel barrier between compartments:
    a. Compartment doors equipped for latching in the open position and capable of being secured with a single padlock.
    b. Door hardware and hinge assemblies made of corrosion-resistant material.
7. Lifting, jacking and rolling provisions.
8. Manufacturer's Instruction Nameplate: A factory installed stainless steel plate and screws permanently affixed to a non-removable part in the low-voltage compartment and located so that it is readable with cables in place.
9. Transformer Tank: Sealed tank construction with welded main cover and bolted tamper-resistant handhole for access to internal connections.
10. Tank grounding provisions in high- and low-voltage compartments.
11. Low-voltage Bushings: Tinned, spade type.
12. High-voltage Bushings: Porcelain, live-front arrangement.

13. High-voltage Entrance: Three, cast resin bushings with phase barriers between bushings.
14. Terminals arranged for cabling from below.
15. Identification: Identify transformers in accordance with Section 26 00 00, General Electrical Provisions, identifying the transformer identification number, primary and secondary power identification and voltage.

C. Accessories:
1. Lightning arrester mounting pads with three lightning and surge over voltage arrestors.
2. Gang-operated internal oil-immersed load break switch with bayonet primary expulsion fuses. Furnish with Bayonet dual sensing fusing device and fuses capable of breaking transformer full load current and provided with oil drip shield.
3. Where drawings require loop feed, furnish 2 (2) two-position under-oil gang-operated switches to be used for sectionalizing and loop feed connections.
4. Fill plug and automatic pressure relief device.
5. Drain valve and sampler.
6. Manually operated de-energized tap changer with handle.
7. Liquid-level gage with alarm contacts.
8. Vacuum-pressure gage with alarm contacts where shown on the drawings.
9. Dial-type thermometer with alarm contact.
10. A NEMA 4 control cabinet with all switch contacts wired to terminal blocks. Provision for padlocking.
11. Oil required to place transformer into service.

D. Sound Level
1. The transformer and auxiliary cooling equipment shall be designed and constructed to minimize the audible noise generated with the transformer energized at rated voltage and with all auxiliary cooling equipment in operation. The acceptable noise level shall be in accordance with NEMA standard TR 1.

E. Nameplates
1. Transformer shall be furnished with a non-corrosive diagrammatic nameplate, permanently attached with non-corrosive hardware. The diagrammatic nameplate shall include the name of the manufacturer of the equipment as well as the location where the transformer was manufactured and tested. In addition, the nameplate shall contain all connection and rating information ANSI.

F. Finish
1. The transformer shall be thoroughly cleaned and phosphortized, paint with at least one corrosion inhibiting primer and one finish coat to provide a minimum total dry-film thickness of not less than 3 mils. All surfaces shall be clean and smooth, clear of burrs and blemishes, all external welds ground smooth and all sharp corners eliminated before any rust proofing or paint is applied. Finish shall be ANSI 61.

G. Transformer Testing: The following factory tests shall be performed in accordance with the latest revision of ANSI Standard Test Code for Transformers, C57.12.90 and C57.12.91.
1. Resistance measurements of all windings on the rated voltage connection of each unit and at the tap extremes of one unit only of a given rating.
2. Ratio tests on the rated voltage connection and on all tap connections.
3. Polarity and phase-relation tests on the rated voltage connection.

4. No-load loss at rated voltage on the rated voltage connection.
5. Exciting current at rated voltage on the rated voltage connection.
6. Impedance and load loss at rated current on the rated voltage connection of each unit and on the tap extremes of one unit only of a given rating.
7. Temperature Test: Tests shall be made only when there is not available a record of a temperature test made in accordance with ANSI Standards on a duplicate or essentially duplicate unit. Tests, when made, shall be made under conditions specified in American Standards for Transformers and on one unit only of a given rating.
8. Applied potential tests.
9. Induced potential tests.

H. Product and Manufacturer: Provide one of the following:
1. Maddox
2. Square D
3. General Electric Company.
4. ABB.
5. Siemens.
6. Or engineer approved equal

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment so that sufficient access and working space is provided for ready and safe operation and maintenance. Working space at least 10 feet in front of medium-voltage compartment access and 3 feet around other sides. Clearance from structures shall be in accordance with code requirements and Rocky Mountain Power (RMP) manual 2016, 4th edition, paragraph 4.6, Figure 9.

B. Install transformer on concrete pad vault per Provo Power details.

C. Set taps for proper voltage at service distribution equipment.

D. Unless otherwise shown on the Drawings, install ground rod directly beneath transformer. Connect grounding electrode conductor(s) to ground rod. Where transformers are to be mounted on existing concrete slabs, drill slab for ground rod penetration. Connect to underground grounding loop.

++ END OF SECTION ++

SECTION 26 13 13

MEDIUM-VOLTAGE CIRCUIT BREAKER SWITCHGEAR

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install an indoor, free-standing metal-clad, medium-voltage switchgear lineup complete and operational with separate neutral grounding resistor. The metal-clad switchgear assembly shall consist of deadfront vertical sections.

B. The manufacturer of the medium-voltage switchgear shall also be the manufacturer of all major components therein.

C. Provide anchorage and support design, including seismic, for medium-voltage switchgear in accordance with General Electrical Provisions under Division 26.

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturer shall have a minimum of five years of experience of producing substantially similar equipment and shall be able to show evidence of at least five installations in satisfactory operation for at least five years.

B. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown and specified.
   1. ANSI C37.010, Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
   2. ANSI C37.04, Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
   3. ANSI C37.06, Switchgear-AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
   4. ANSI C37.09, Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
   5. ANSI C37.11, Power circuit breaker control.
   6. ANSI C37.20.2, Metal-clad and Station-Cubicle Switchgear.
   7. ANSI C37.90, Standard for Relays and Relay Systems Associated with Electric Power Apparatus.
   8. ANSI C37.100, Definitions for Power Switchgear.
   9. ANSI C57.13, Instrument Transformers, Standards for.
   10. NEMA SG-2, High Voltage Fuses.
   11. NEMA SG-4, Alternating Current High Voltage Power Circuit Breakers.
   12. NEMA SG-5, Power Switchgear Assemblies.
   13. UL, Underwriters Laboratories.

C. For the equipment specified herein, the manufacturer shall be ISO 9000, 9001 or 9002 certified.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Submit for approval, to both the ENGINEER and OWNER, copies of manufacturer's technical information for equipment proposed for use. Submittals shall include the following:
      a. Dimensional information.
      b. One-line diagrams.
      c. Technical specifications.
      d. Catalog cuts with supplied options and accessories clearly identified.
      e. Construction details of enclosure.
      f. Schematic control diagrams for breaker control and all other controls.

B. Certification of Ratings: Submit for approval copies of certifications as follows:
   1. The integrated switchgear assembly shall have a BIL rating established by test on switchgear of the type to be furnished under this Section. Certified test abstracts establishing such ratings shall be furnished.

C. Approval of the switchgear submittal will be contingent upon prior approval of the preliminary power system studies.

D. Operation and Maintenance Data:
   1. Submit complete installation, operation and maintenance manuals including test reports, maintenance data and schedules, description of operation and spare parts information.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver materials to the site to ensure uninterrupted progress of the Work. Deliver anchor bolts and anchorage devices which are to be embedded in cast-in-place concrete in ample time to prevent delay of the Work.

B. All boxes, crates and packages shall be inspected by CONTRACTOR upon delivery to the site. Notify ENGINEER of any loss or damage exists to equipment or components. Replace loss and repair damage to new condition in accordance with manufacturer's instructions.

C. Equipment shall be handled and stored in accordance with manufacturer's instructions. One copy of these instructions shall be included with the equipment at time of shipment.

D. Shipping groups shall be designed to be shipped by truck, rail, or ship. Indoor groups shall be bolted to skids. Breakers and accessories shall be packaged and shipped separately.

E. Switchgear shall be equipped to be handled by crane. Where cranes are not available switchgear shall be suitable for skidding in place on rollers using jacks to raise and lower the groups.

F. Switchgear being stored prior to installation shall be stored so as to maintain the equipment in a clean and dry condition.

PART 2 - PRODUCTS

2.1 RATINGS

A. The medium-voltage distribution system will be low resistance grounded wye.

B. The ratings for the integrated switchgear assembly shall be as shown on the drawings.

2.2 MATERIALS

A. General:
   1. The metal-clad switchgear assembly shall consist of multiple, self-supporting bays. The sections shall contain drawout vacuum circuit breakers and controls as shown on the Drawings.

B. Construction:
   1. The switchgear shall consist of a stationary structure constructed from individual vertical sections as shown on the Drawings. The vertical sections shall be bolted together to form a rigid metal-clad switchgear assembly. Metal sheets shall provide grounded metal barriers between adjacent sections.
   2. Each breaker compartment shall be equipped to house a removable breaker element. The breaker levering mechanism shall be cell mounted. A steel shutter shall automatically cover the stationary primary disconnecting contacts when the breaker is in the disconnected position or out of the cell. Rails shall allow the withdrawal of each circuit breaker for inspection and maintenance without the use of a separate lifting device. Breaker can be moved to disconnected position within the enclosure. Lift truck shall be required to move the breaker out of the cubicle for maintenance.
   3. Power bus shall be tin-plated copper. Bare copper, neutral bus. Ground bus shall be full length, copper. All of the main bus shall have porcelain insulators to ground. This shall include porcelain inserts in the bus support barriers, porcelain standoff insulators and porcelain sleeves for the stationary primary disconnects.
   4. All power terminations shall be single conductor potheads for single conductor, copper conductors.
   5. The main bus shall have epoxy flame-retardant, track-resistant insulation. Bus supports between units shall be flame-retardant, track-resistant, glass polyester. The bus shall be braced to withstand fault currents equal to the close and latch rating of the circuit breakers contained therein.
   6. All sections indicated as "SPACE" on the Drawings shall be provided with all necessary provisions for a future circuit breaker. All PTs, CTs, relays, etc. shall be provided ready for insertion of a circuit breaker.
   7. Where shown on the Drawings, provide an additional vertical section which shall include bus taps. Provide bus lugs for the termination of 3-500 KCMIL conductors per phase.

C. Circuit Breakers:
   1. Each circuit breaker shall be horizontal, draw-out type, capable of being withdrawn on rails. The breakers shall be operated by a motor-charged spring stored energy mechanism. The spring may be charged manually in an emergency or during maintenance procedures.
   2. Each circuit breaker shall have three vacuum interrupter assemblies that are separately mounted on glass polyester insulators. Each vacuum interrupter assembly shall have a

contact wear indicator which does not require any tools to indicate the

contact wear. The current transfer from the vacuum interrupter moving stem to the breaker main conductor shall be a non-sliding design. The circuit breaker shall not utilize air or oil dash pots for minimizing vacuum interrupter contact "bounce," upon opening.

3. Each circuit breaker shall meet the requirements of ANSI Standards, C37.010, C37.04, C37.06, C37.07, C37.09, C37.11, and C37.100, and shall be as shown on the drawings.
4. Each breaker shall have the number of status (52a and 52b) contacts as required by the Drawings and four mechanism cell switches (switches close when circuit breaker is in the "TEST" or "WITHDRAWN" position).
5. The breakers shall be electrically operated by 120 volt AC control power. The control power shall be derived from CPTs provided by switchgear manufacturer.
6. The two main circuit breakers and the bus tie circuit breaker shall be electrically and mechanically interlocked in order to prevent not more than two of these breakers from being closed at any one time.

D. Remote Racking
   1. Provide a Remote Racking Device to allow remote insertion and removal of a circuit breaker from its cradle and racking between the disconnected position and the connected position. Operation capable of being performed from outside the arc flash zone as described by NFPA 70E/CSA Z462.

E. Surge Arresters: 8.4 KV intermediate class surge arresters shall be provided and connected at the incoming terminations for each line and securely grounded to the metal structure.

F. Protective Relaying (Main breakers):
   1. Each 15 KV circuit breaker shall be provided with a microprocessor based, front-panel mounted overcurrent trip device which shall operate from 120 volt AC control power. The device shall sense true RMS current in each phase and ground. The ground element shall be capable of either residual or zero sequence ground fault detection or deactivation.
   2. The unit shall provide the following protective functions:
      a. Phase/ground/neutral time and instantaneous overcurrent.
      b. Negative sequence time overcurrent.
      c. Undervoltage and overvoltage.
      d. Breaker failure.
      e. Manual close control.
      f. Neutral (3Io) time overcurrent.
      g. Percent and instantaneous transformer differential protection.
      h. Volts per hertz.
      i. Overfrequency.
      j. Underfrequency.
   3. The unit shall have the following additional features:
      a. Display of individual phase currents, ground current, magnitude and phase of trip current, peak current for each phase and ground since last reset, and CT ratio.
      b. Total harmonic distortion.
      c. Adjustable CT ratio.
      d. Separate time-overcurrent (ANSI 51) and instantaneous (ANSI 50) trip contacts.
      e. Unit failure alarm contact.
      f. Trip alarm contact.
      g. Programmable lockout or self reset after trip.

h. Integral manual testing capability.
4. Communications Capability:
   a. Ethernet Communications.
   b. Four relay outputs.
   c. Four digital inputs.

G. Protective Relaying (Feeder and Tie Breakers):
1. Each circuit breaker shall be provided with a microprocessor based, front-panel mounted overcurrent trip device which shall operate from 120 volt AC control power. The device shall sense true RMS current in each phase and ground. The ground element shall be capable of either residual or zero sequence ground fault detection or deactivation.
2. The unit shall provide the following protective functions:
   a. Phase/ground/neutral time and instantaneous overcurrent.
   b. Breaker failure.
   c. Manual close control.
3. The unit shall have the following additional features:
   a. Display of individual phase currents, ground current, magnitude and phase of trip current, peak current for each phase and ground since last reset, and CT ratio.
   b. Adjustable CT ratio.
   c. Separate time-overcurrent (ANSI 51) and instantaneous (ANSI 50) trip contacts.
   d. Unit failure alarm contact.
   e. Trip alarm contact.
   f. Programmable lockout or self reset after trip.
   g. Integral manual testing capability.
   h. Zone-selective interlocking capability for short time and ground fault protection.
4. Communications Capability:
   a. Ethernet Communications.
   b. Four relay outputs.
   c. Four digital inputs.

H. Additional Controls and Equipment:
1. Furnish a programmable logic controller to control the operation of the circuit breakers to facilitate automatic switching to alternate sources upon loss of power in a source. The automatic controls shall ensure an open transition source transfer to prevent any two sources from being connected to the same bus simultaneously. The automatic transfer shall occur upon a source undervoltage, frequency out of range, or loss of phase.
2. Coordinate operation with generator controller.
3. Furnish all necessary wiring and auxiliary devices including current and potential transformers, control power transformers and control relays. Control relay contacts shall be adequately rated for the currents to be switched.
4. Furnish necessary control power transformers, fuses, relays and contactors, etc. for a station power automatic throwover scheme. The automatic throwover controls shall feed an external, 120/240 volt panelboard.
5. Furnish a DC power distribution panel with main breaker and all required branch breakers for serving all DC power loads within switchgear.
6. Furnish a Gateway to translate network communications into Ethernet protocol as shown on the network drawings.
7. Nameplates, plastic, as shown on the drawings.
8. All breakers shall include a manually resettable, lockout (Device No. 86) relay. Relay shall have the quantity and type of contacts as required by the Drawings.

9. Metering sections as shown on the drawings shall be provided. Each incoming line shall have a complete metering section built in accordance with all applicable standards and requirements. Doors shall have provisions for padlocking.

I. Conductors:
   1. Small wiring, fuse blocks, and terminal blocks within each vertical section shall be furnished as shown on the Drawings and as required. Each control wire shall be labeled with wire markers. Control wiring shall be Type SIS, No. 14 AWG, minimum. Terminal blocks shall be provided for customer connections to other apparatus.
   2. Furnish all internal wiring for controls, DC control power and AC power circuits.

J. Instrument Transformers:
   1. Ring type current transformers shall be furnished as specified, as shown on the Drawings and verified by the Power System Study. The thermal and mechanical ratings of the current transformers shall be coordinated with the circuit breakers. Their accuracy rating shall be equal or higher than ANSI standard requirements. Shorting terminal blocks shall be furnished on the secondary of all the current transformers.
   2. Voltage and control power transformers of the quantity and ratings as shown on the Drawings shall be supplied. Voltage transformers and control power transformers shall be mounted in drawout drawers. Rails shall be provided for each drawer to permit easy inspection testing and fuse replacement. Shutters shall isolate primary bus stabs when drawers are withdrawn. Furnish a main secondary circuit breaker for each control power transformer. A mechanical interlock shall be provided which shall require the secondary breaker to be open before the CPT drawer or CPT primary fuse drawer can be opened.
   3. Instrument transformers shall have metering accuracies compatible with the relays and microprocessor-based metering equipment.

K. Metering:
   1. Provide a metering device for each incoming main circuit breaker with current and potential transformers as shown on the Drawings.
   2. Metering device shall monitor and display the following information:
      a. Phase amperes (each phase): 0.3 percent accuracy.
      b. Voltage, phase-to-phase: 0.3 percent accuracy.
      c. Watts: 0.6 percent accuracy.
      d. Vars: 0.6 percent accuracy.
      e. Power factor: 1.0 percent accuracy.
      f. Frequency: 0.1 Hz.
      g. Kilowatthours: 6 percent accuracy.
      h. Kilovarhours: 0.6 percent
      i. Percent current total harmonic distortion in each phase.
      j. Percent voltage total harmonic distortion between each phase.
   3. The unit shall have the following additional features:
      a. Trend analysis which shall display minimum and maximum values for each metered parameter with date and time of each occurrence.
      b. The input range of the device shall accommodate external current transformers with ranges from 100/5 to 5000/5 and potential transformers from a ratio of 120:120 to 500,000:120.
      c. Alarm contacts rated five amps at 120 VAC.
      d. Communications capability via a communications module, if required. Protocol shall be as shown on the drawings.

4. Control power shall be drawn from the monitored incoming AC line. The device shall have non-volatile memory and not require battery backup. In the event of a power failure, the device shall retain preset parameters.

L. Manufacturer's Nameplates:
   1. Factory installed engraved manufacturer's nameplates, mounted on the face of the assembly, and shall be furnished for all main, tie and feeder breakers. These nameplates shall be laminated plastic with 3/4-inch minimum, white characters on a black background or match existing, secured with stainless steel screws. These nameplates shall also contain item designation, equipment served breaker frame size and breaker trip rating.
   2. All control components within the assembly shall be identified in correspondence to appropriate designations on the manufacturer's wiring diagrams.

M. Accessories:
   1. Maintenance tool for manually charging the breaker closing spring and manually opening the shutter.
   2. Lift truck.
   3. Manual ground and test device. Furnish for each breaker current rating 1 amp and amp).
   4. Levering crank for moving the breaker between "TEST" and "CONNECTED" positions.
   5. Test jumper for electrically operating the breaker while out of its compartment.
   6. Breaker lifting yoke used for attachment to breaker for lifting breaker on or off compartment rails.
   7. One set of rail extensions and rail clamps.
   8. Any additional devices as required and as shown on the Drawings.

N. UPS Power Source:
   1. Switchgear manufacturer shall provide minimum 90 minutes of uninterruptible power supply for all protective relaying, controls, and metering.
   2. Provide a continuous-duty, on-line, solid state, dual conversion, single-phase input (using input voltage from the switchgear), single-phase 120VAC true sinewave output uninterruptible power system.
   3. The UPS system shall consist of the following major components:
      a. Rectifier and battery charger.
      b. Inverter.
      c. Batteries and battery disconnect switch.
      d. Automatic static bypass switch.
      e. External maintenance bypass switch.
      f. Integral control and monitoring panel.

O. Infrared Window or Thermal sensor:
   1. Provide one of the following where applicable:
      a. Provide infrared windows for viewing of the line and load side terminals of the main breaker(s).
         1) Size: 4 inches
         2) Window to be provided with a coating to seal the optic prior to assembly to protect against degradation.
         3) Window to be provided with hand turn door latch with identification plate.
         4) Mount window with high temperature silicon gaskets.
         5) Product and Manufacturer: Provide the following:
            a) Fluke ClirVu® CV Series

b) Or engineer approved equal

2. Thermal sensors:
   a. Provide thermal sensors with remote display.
   b. Units shall not require batteries.
   c. Units shall be capable of remote monitoring without opening the switchgear doors.

P. Neutral Grounding Resistor:
   1. The neutral grounding resistor will consist of high-grade chromium stainless steel or nichrome elements and terminals of high corrosion resistance, double insulated, durable for long years of service, and having extremely high & stable electrical resistivity.
   2. Size resistor for continuous operation under voltage and current conditions identified on the project drawings.
   3. Edgewound type with welded connections between units.
   4. Edgewound helix strap wound around a refractory core reinforced by longitudinal steel supports.
   5. Each resistor element individually supported at each end by ceramic insulators in such a manner that one end of the helix bar support is freely attached to a roller which shall permit expansion f the supporting bar when subject to high temperatures.
   6. Resistor elements shall be electrically joined by stainless steel connectors welded to the stainless-steel terminals to provide a positive electrical path. From neutral connection point to ground connectors, all electrical circuitry shall be welded.
   7. Resistor shall have provisions for direct terminations of incoming neutral cable and grounding conductor in dedicated conduit stub ups through the concrete mounting pad and inside the safety frame enclosure.
   8. Furnish ground bus with mechanical lugs suitable for No. 2 AWG to 4/0 AWG bare copper wire.
   9. In addition to ground bus lugs, furnish mechanical ground lugs suitable for No. 2 AWG to 4/0 AWG bare copper wire diagonally opposite legs.
   10. If more than one resistor frame is required, series connections will be solid copper bus on grid style resistors, teflon wire on wirewound style resistors.
   11. The resistor frame(s) will be mounted on standoff insulators with a rating equal to or greater than the line-to-neutral voltage.
   12. The resistor will be time rated for 10 second 76 deg C (168 deg F) rise extended time 61 deg C (142 deg F) rise continuous 38.5 deg C (101 deg F).
   13. Suitable for operation without derating at the site conditions.
   14. High Voltage Units (Above 600 Volts Line-to-Line)
       a. Assemblies will utilize an open frame free-standing enclosure housing both the control section and the high voltage compartment with step-down transformer. Furnish enclosure with legs to elevate enclosure minimum six inches (6”) above top of concrete pad.
       b. Painted galvanneal steel, ANSI-61 gray.
   15. Furnished with removable lifting angles and/or plates for crane hooks or slings for ease of transport and installation, and/or removable base channels for positioning with rollers.
   16. Sufficient space for mounting current transformers and other specified control equipment and accessories.
   17. Enclosure sides will be removable to allow for access during construction and maintenance.
   18. CONTROLS
       a. All control circuitry will operate on 120 Volts AC.

b. All control wiring will be 14 AWG minimum, rated at 600 Volts AC. Wiring must be sufficiently supported within the enclosure.
c. The high resistance neutral grounding equipment will contain the following equipment on an operator's panel on the front of the unit as standard:
    1) Line Disconnect Switch
    2) Test Push-button
    3) A digital display unit containing the following functions:
        a) Fault Reset Push-button
        b) Green Light to Indicate "Normal" Operating Status
        c) Flashing red Light to Indicate "Fault" Status
        d) Red Light to Indicate "Harmonic" Status
        e) Fault reset push-button
        f) Alarm silence push-button
        g) Pulse on/off push-button
        h) Amber light to indicate "pulse" status
        i) Indication of Under-Voltage condition
        j) Indication of Under-Current condition
        k) Ethernet IP port for Communications. Provide protocol convertor as required.
        l) Software to Configure and Monitor system remotely
        m) Software to Data Log / Trend abnormal conditions
        n) Single setpoint Meter Relay
d. Other standard equipment is as follows:
    1) Alarm Relaying for Local and Remote Annunciation
    2) Pulsing Contactor and Timer
    3) Grounding Transformer(s) - High Voltage Units Only
    4) Copper Grounding Buss - Free Standing Units Only
e. The relay to monitor fundamental voltage and current will incorporate an adjustable time delay function to avoid spurious alarms.
f. The relay to monitor harmonic voltage and current will incorporate an adjustable time delay function to avoid spurious alarms.
g. The optional portable ground detector will be a "split core" type ammeter with a multiple range switch. The clamp must be capable of enveloping a minimum 6" diameter. A short circuiting switch should be provided, along with a carrying case. The handle must be insulated for use on 15,000 volt system.
h. Product and Manufacturer: Provide one of the following:
    1) Post Glover
    2) General Electric Industrial
    3) Hilkar Electric Inc.
    4) Milwaukee Resistor Corp.
    5) Avtron Loadbank Inc.
    6) Or engineer approved equal

2.3 SWITCHGEAR MANUFACTURERS

A. Product and Manufacturer: Provide one of the following:
    1. Schneider Electric
    2. Siemens
    3. GE Power
    4. Or engineer approved equal

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment so that sufficient access and working space is provided for ready and safe operation and maintenance.

B. Install equipment on concrete pad as shown on the Drawings. Coordinate pad dimensions to fit equipment furnished.

3.2 FACTORY TESTS

A. The manufacturer shall perform standard factory tests on each circuit breaker. The factory tests shall be witnessed by the ENGINEER. Include the cost of the witness testing in the price. The cost shall include all transportation, lodging and meals.

3.3 FIELD INSPECTION AND TESTS

A. Provide the services of an authorized service representative of the equipment manufacturer to make site visits to supervise the field testing to be performed by CONTRACTOR. The manufacturer's representative shall inform the OWNER if the equipment has been correctly installed and shall submit the factory and field test results to the OWNER and ENGINEER. The manufacturer's representative shall certify, in writing, that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations.

B. Perform the following minimum tests and checks before energizing equipment.
   1. Perform insulation resistance tests on each bus section, phase-to-phase and each phase-to-ground for a period of one minute at 2500 VDC. Minimum insulation resistance shall be 5000 megohms.
   2. After successful completion of insulation resistance test, perform an overpotential test on each bus section, each phase-to-ground for a period of one minute at manufacturer's recommended voltage.
   3. Inspect all mechanical and electrical interlocks for proper operation.
   4. Perform insulation resistance test on all control wiring at 1000 VDC after disconnecting devices. Minimum, measured insulation resistance shall be one megohm.

C. The manufacturer shall submit the test results to the ENGINEER to confirm that the switchgear assembly design has been tested to substantiate conformance with the applicable ANSI and NEMA Standards. The tests shall verify not only the performance of the switch or integrated switch and fuse, but also the suitability of the enclosure venting, rigidity and bus bracing. In addition, the switchgear assembly shall be factory tested in accordance with ANSI Standard C37.20.3. and these Specifications.

D. Perform any other tests recommended by the equipment manufacturer.

3.4 MANUFACTURER'S SERVICES

A. A factory trained representative shall be provided for installation supervision, start-up and test services and operation and maintenance personnel training services. The representative shall make a minimum of 3 visits, minimum 8 hours on-site for each visit,

to the site. The first visit shall be for assistance in the installation of equipment. The second visit shall be for checking the completed installation and start-up of the system. The third visit shall be for training. Manufacturer's representative shall test operate the system in the presence of the ENGINEER and verify that the 15 KV switchgear conform to requirements. Representative shall revisit the job site as often as necessary until all trouble is corrected and the installation is entirely satisfactory.

B. All costs, including travel, lodging, meals and incidentals, shall be considered as included in CONTRACTOR'S bid price.

3.5 FIELD ADJUSTMENTS

A. Relay settings on the microprocessor protective device shall be performed by CONTRACTOR in the field in accordance with the recommended settings designated in the coordination study.

++ END OF SECTION ++

SECTION 26 13 15

MEDIUM-VOLTAGE PAD-MOUNTED SWITCHGEAR

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. Provide all labor, materials, equipment and incidentals, including concrete pad, as shown on the Drawings, specified and required to furnish and install free-standing medium-voltage pad-mounted switchgear complete and operational.
   2. The pad-mounted gear shall consist of a single self-supporting enclosure, containing source load break switches and feed vacuum fault interrupter switches with the necessary accessory components, all completely factory-assembled and operationally checked. The interrupter switches shall be enclosed within an inner grounded steel compartment for electrical isolation and for protection from contamination. Switch terminals shall be equipped with bushings rated 600 amperes continuous and bus terminals shall be equipped with bushing wells rated 200 amperes continuous to provide for elbow connection. Bushings and bushing wells shall be mounted on the walls of the inner compartment and shall extend into termination compartments. A termination compartment shall be provided for each three-phase switch and each three-phase set of bus terminals.
   3. Provide anchorage and support design, including seismic, for medium-voltage pad-mounted switchgear in accordance with General Electrical Provisions under Division 26.

1.2 QUALITY ASSURANCE

A. Manufacturer’s Qualifications:
   1. Manufacturer shall have a minimum of five years of experience of producing substantially similar equipment and shall be able to show evidence of at least five installations in satisfactory operation for at least five years.

B. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown and specified.
   1. of ANSI C57.12.28, covering enclosure integrity for pad-mounted equipment.
   2. Article 710.21(e) in the National Electrical Code.
   3. All portions of ANSI, IEEE, and NEMA standards applicable to the basic switch components.
   4. NFPA 70, National Electrical Code.
   5. UL, Underwriters Laboratories.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's technical information for equipment proposed for use. Submittals shall include the following:
      a. Dimensional information.
      b. Three-line diagrams.
      c. Technical specifications.

d. Catalog cuts.
e. Construction details of enclosure.

B. Certification of Ratings: Submit for approval copies of certifications as follows:
1. The integrated switchgear assembly shall have a BIL rating established by test on switchgear of the type to be furnished under this Specification. Certified test abstracts establishing such ratings shall be furnished.

C. Operation and Maintenance Manuals:
1. Submit complete installation, operation and maintenance manuals including test reports, maintenance data and schedules, description of operation and spare parts information.

PART 2 - PRODUCTS

2.1 RATINGS

A. The ratings for each integrated switch assembly shall be as shown on the drawings.

2.2 MATERIALS

A. General:
1. The manufacturer of the pad-mounted gear shall be completely and solely responsible for the performance of the basic switch components as well as the complete integrated assembly as rated.
2. The manufacturer shall furnish, upon request, certification of ratings of the basic switch components and/or the integrated pad-mounted gear assembly consisting of the switch components in combination with the enclosure.
3. Switches shall utilize less-flammable FR3 type insulating dielectric media.

B. Insulators
1. The interrupter-switch mounting insulators shall be of a cycloaliphatic epoxy resin system with characteristics and restrictions as follows:
a. Operating experience of at least 25 years under similar conditions.
b. Adequate leakage distance established by test per IEC Publication 507, "Artificial Pollution Test on High Voltage Insulators to be Used on AC Systems."
c. Adequate strength for short-circuit stress established by test.
d. Conformance with applicable ANSI standards.
e. Homogeneity of the cycloaliphatic epoxy resin throughout each insulator to provide maximum resistance to power arcs. Ablation due to high temperatures from power arcs shall continuously expose more material of the same composition and properties so that no change in mechanical or electrical characteristics takes place because of arc-induced ablation. Furthermore, any surface damage to insulators during installation or maintenance of the pad-mounted gear shall expose material of the same composition and properties so that insulators with minor surface damage need not be replaced.

C. High-Voltage Bus
1. Bus and interconnections shall consist of aluminum bar of 56% IACS conductivity.
2. Bus and interconnections shall withstand the stresses associated with short-circuit currents up through the maximum rating of the pad-mounted gear.

3. Bolted aluminum-to-aluminum connections shall be made with a suitable number of galvanized steel bolts, with two Belleville spring washers per bolt, one under the bolt head and one under the nut. Bolts shall be tightened to 50 foot-pounds torque.
4. Before installation of the bus, all electrical contact surfaces shall first be prepared by machine-abrading to remove any aluminum-oxide film. Immediately after this operation, the electrical contact surfaces shall be coated with a uniform coating of an oxide inhibitor and sealant.
5. Tie bus, where furnished, shall consist of continuous, one-piece sections of aluminum bar with no intermediate splices. Flexible braid or cable shall not be used.

D. Provisions for Grounding
1. A ground-connection pad shall be provided in each termination compartment of the pad-mounted gear.
2. The ground-connection pad shall be constructed of no less than 3/8-inch-thick steel. It shall be nickel plated and welded to the enclosure and shall have a short-circuit rating equal to that of the pad-mounted gear.
3. Ground-connection pads shall be coated with a uniform coating of an oxide inhibitor and sealant prior to shipment.
4. A copper rod, connected to the ground-connection pad, shall be provided in each termination compartment for switches and bus. The rod shall have a diameter no less than 3/8-in. and extend across the full width of the compartment to allow convenient grounding of cable concentric neutrals and accessories and shall have a short-circuit rating equal to that of the pad-mounted gear.
5. Continuous copper ground bus shall be provided across the full width of each termination compartment for fuses. For each fuse mounting, there shall be a ground ring made of 3/8-inch diameter copper rod bolted to the ground bus and placed to allow convenient grounding of cable concentric neutrals and accessories. Ground rings and bus shall have a short-circuit rating equal to that of the pad-mounted gear

E. Bushings and Bushing Wells
1. Bushings and bushing wells shall conform to ANSI/IEEE Standard 386.
2. Bushings and bushing wells shall be of a cycloaliphatic epoxy resin system with characteristics and restrictions as follows:
    a. Operating experience of at least 15 years under similar conditions.
    b. Adequate leakage distance for in-air application established by test per IEC Publication 507, "Artificial Pollution Test on High Voltage Insulators to be Used on AC Systems."
    c. Adequate strength for short-circuit stress established by test.
    d. Conformance with applicable ANSI standards.
    e. Homogeneity of the cycloaliphatic epoxy resin throughout each bushing or bushing well to provide maximum resistance to power arcs. Ablation due to high temperatures from power arcs shall continuously expose more material of the same composition and properties so that no change in mechanical or electrical characteristics takes place because of arc-induced ablation.
3. Bushings and bushing wells shall be mounted in such a way that the semiconductive coating is solidly grounded to the enclosure.
4. Bushings rated 600 amperes continuous shall have a removable threaded stud so that the bushings are compatible with all 600 ampere elbow systems—those requiring a threaded stud as well as those that do not.

F. Termination Compartments

1. Termination compartments for switches shall have bushings, and termination compartments for fuses shall have bushing wells to permit connection of elbows. The bushings and bushing wells shall be mounted on the interior walls at a minimum height of 33 inches above the enclosure base.
2. Termination compartments for bus shall have bushing wells to permit connection of elbows. The bushing wells shall be mounted on the interior walls at a minimum height of 25 inches above the enclosure base.
3. Termination compartments for bushings rated 600 amperes continuous shall be of an adequate depth to accommodate two 600 ampere elbows mounted piggyback, encapsulated surge arresters or grounding elbows mounted on 600 ampere elbows having 200 ampere interfaces, or other similar accessory combinations without the need for an enclosure extension.
4. Termination compartments for bushing wells rated 200 amperes continuous shall be of an adequate depth to accommodate 200 ampere elbows mounted on portable feed-thrus or standoff insulators, or other similar accessory combinations without the need for an enclosure extension.
5. Termination compartments shall be provided with one parking stand for each bushing or bushing well. The parking stand shall be located immediately adjacent to the associated bushing or bushing well and shall accommodate standard feedthroughs and standoff insulators, and other similar accessories.
6. Each termination compartment for a switch shall be equipped with a viewing window to allow visual inspection of interrupter switch blades to allow positive verification of switch position.
7. Each termination compartment for a set of fuses shall be equipped with a set of viewing windows to allow visual inspection of blown-fuse indicators.

G. Enclosure
1. The pad-mounted gear enclosure shall be of unitized monocoque (not structural-frame-and-bolted-sheet) construction to maximize strength, minimize weight, and inhibit corrosion.
2. The basic material shall be 11-gauge hot-rolled, pickled and oiled steel sheet.
3. All structural joints and butt joints shall be welded, and the external seams shall be ground flush and smooth. The gas-metal-arc welding process shall be employed to eliminate alkaline residues and to minimize distortion and spatter.
4. To guard against unauthorized or inadvertent entry, enclosure construction shall not utilize any externally accessible hardware.
5. The base shall consist of continuous 90 degree flanges, turned inward and welded at the corners, for bolting to the concrete pad.
6. The door openings shall have 90 degree flanges, facing outward, that shall provide strength and rigidity as well as deep overlapping between doors and door openings to guard against water entry.
7. Gasketing between the roof and the enclosure shall guard against entry of water and airborne contaminants and shall discourage tampering or insertion of foreign objects.
8. An internal steel-enclosed compartment shall encase the interrupter switches and fuses for electrical isolation and protection from contamination. The compartment shall have a galvanized steel sheet floor to exclude foliage and animals. The floor shall have screened drain vents to allow drainage if the enclosure is flooded. The top of this compartment shall be gasketed to provide sealing with the enclosure roof.
9. Insulating barriers of NEMA GPO3-grade fiberglass-reinforced polyester shall be provided for each interrupter switch where required to achieve BIL ratings. Additional insulating barriers of the same material shall isolate the tie bus (where furnished).
10. Full-length steel barriers shall separate adjoining termination compartments.

11. Lifting tabs shall be removable. Sockets for the lifting-tab bolts shall be blind-tapped. A resilient material shall be placed between the lifting tabs and the enclosure to help prevent corrosion by protecting the finish against scratching by the tabs. To further preclude corrosion, this material shall be closed-cell to prevent moisture from being absorbed and held between the tabs and the enclosure in the event that lifting tabs are not removed.
12. The enclosure shall be provided with an instruction manual holder.
13. The following optional feature should be specified as required:
14. To guard against corrosion due to extremely harsh environmental conditions, the entire exterior of the enclosure shall be fabricated from 11-gauge Type 304 stainless steel.

H. Interrupter Switches
   1. Interrupter switches shall be enclosed in an inner steel compartment and shall be provided with bushings rated 600 amperes continuous to permit connection of elbows external to the switch compartment.
   2. Interrupter switches shall have a three-time duty-cycle fault-closing rating equal to or exceeding the short-circuit rating of the pad-mounted gear. These ratings define the ability to close the interrupter switch three times against a three-phase fault with asymmetrical current in at least one phase equal to the rated value, with the switch remaining operable and able to carry and interrupt rated current. Tests substantiating these ratings shall be performed at maximum voltage with current applied for at least 10 cycles. Certified test abstracts establishing such ratings shall be furnished upon request.
   3. Interrupter switches shall be operated by means of an externally accessible 3/4 inch hex switch-operating hub. The switch-operating hub shall be located within a recessed stainless-steel pocket mounted on the side of the pad-mounted gear enclosure and shall accommodate a 3/4-inch deep-socket wrench or a 3/4-inch shallow-socket wrench with extension. The switch-operating-hub pocket shall include a padlockable stainless-steel access cover that shall incorporate a hood to protect the padlock shackle from tampering. Stops shall be provided on the switch-operating hub to prevent overtravel and thereby guard against damage to the interrupter switch quick-make quick-break mechanism. Labels to indicate switch position shall be provided in the switch-operating-hub pocket.
   4. Each interrupter switch shall be provided with a folding switch-operating handle. The switch-operating handle shall be secured to the inside of the switch-operating-hub pocket by a brass chain. The folded handle shall be stored behind the closed switch-operating-hub access cover.
   5. Interrupter switches shall utilize a quick-make quick-break mechanism installed by the switch manufacturer. The quick-make quick-break mechanism shall be integrally mounted on the switch frame and shall swiftly and positively open and close the interrupter switch independent of the switch-operating-hub speed.
   6. Each interrupter switch shall be completely assembled and adjusted by the switch manufacturer on a single rigid mounting frame. The frame shall be of welded steel construction such that the frame intercepts the leakage path which parallels the open gap of the interrupter switch to positively isolate the load circuit when the interrupter switch is in the open position.
   7. Interrupter switch contacts shall be backed up by stainless-steel springs to provide constant high contact pressure.
   8. Interrupter switches shall be provided with a single blade per phase for circuit closing, including fault closing, continuous current carrying, and circuit interrupting. Spring-loaded auxiliary blades shall not be permitted. Interrupter switch blade

supports shall be permanently molded in place in a unified insulated shaft constructed of the same cycloaliphatic epoxy resin as the insulators.

9. Circuit interruption shall be accomplished by use of an interrupter which is positively and inherently sequenced with the blade position. It shall not be possible for the blade and interrupter to get out of sequence. Circuit interruption shall take place completely within the interrupter, with no external arc or flame. Any exhaust shall be vented in a controlled manner through a deionizing vent.

10. Optional features:
    a. Key interlocks shall be provided to prevent paralleling the two source interrupter switches.
    b. Key interlocks shall be provided to guard against opening the door(s) of fuse-termination compartment(s) unless all switches are locked open.
    c. Mounting provisions shall be provided to accommodate one three-phase fault indicator with three single-phase sensors in each switch-termination compartment.
    d. Interrupter switch bushings rated 600 amperes continuous shall be provided without studs.

2.3 LABELING

A. Hazard-Alerting Signs
   1. All external doors shall be provided with "Warning—Keep Out—Hazardous Voltage Inside—Can Shock, Burn, or Cause Death" signs.
   2. The inside of each door shall be provided with a "Danger—Hazardous Voltage—Failure to Follow These Instructions Will Likely Cause Shock, Burns, or Death" sign. The text shall further indicate that operating personnel must know and obey the employer's work rules, know the hazards involved, and use proper protective equipment and tools to work on this equipment.
   3. Termination compartments shall be provided with "Danger—Keep Away—Hazardous Voltage—Will Shock, Burn, or Cause Death" signs.

B. Nameplates, Ratings Labels, and Connection Diagrams
   1. The outside of each door (or set of double doors) shall be provided with a nameplate indicating the manufacturer's name, catalog number, model number, date of manufacture, and serial number.
   2. The inside of each door (or set of double doors) shall be provided with a ratings label indicating the following:
      a. Overall pad-mounted gear ratings: nominal voltage, kV; maximum voltage, kV; BIL voltage, kV; power frequency, Hz; short-circuit peak withstand current, amperes, peak; short-circuit one-second short-time withstand current, amperes, RMS, symmetrical; and short-circuit MVA, three-phase symmetrical, at rated nominal voltage.
      b. Main bus ratings: continuous current, amperes; peak withstand current, amperes, peak; and one-second short-time withstand current, amperes, RMS symmetrical.
      c. Switch ratings: continuous current, amperes; load splitting current, amperes; load dropping current, amperes; peak withstand current, amperes, peak; one-second short-time withstand current, amperes, RMS, symmetrical; and three-time duty-cycle fault-closing current, amperes, RMS symmetrical and amperes, peak.
      d. Fuse type and ratings: maximum current, amperes and interrupting current, amperes, RMS, symmetrical.

3. A three-line connection diagram showing interrupter switches, fuses, and bus along with the manufacturer's model number shall be provided on the inside of each door (or set of double doors), and on the inside of each switch-operating-hub access cover.

2.4 ACCESSORIES

1. End fittings and fuse unit, holder and refill unit, or interrupting module and control module shall be furnished for each fuse mounting. In addition, one spare fuse unit, refill unit, or interrupting module shall be furnished.
2. A voltage tester with audio-visual signal capability shall be provided, along with batteries, shotgun clamp-stick adapter, and storage case.

B. A shotgun clamp stick (8 feet, 5 1/2 inches) in length shall be provided complete with canvas storage bag.

2.5 MANUFACTURERS

A. Product and Manufacturer: Provide one of the following:
   1. Maddox
   2. Cooper Electric
   3. General Electric Company
   4. Siemens
   5. Or engineer approved equal

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment so that sufficient access and working space is provided for ready and safe operation and maintenance.

B. Install equipment on concrete pad, as shown on the Drawings. Coordinate the pad dimensions to fit equipment furnished.

3.2 FIELD INSPECTION AND TESTS

A. Provide the services of an authorized service representative of the equipment manufacturer to make site visits to supervise the field-testing to be performed by CONTRACTOR. The manufacturer's representative shall inform the OWNER if the equipment has been correctly installed and shall submit the factory and field test results to the OWNER. The manufacturer's representative shall certify, in writing, that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations.

B. Perform the following minimum tests and checks before energizing equipment:
   1. Perform insulation resistance tests on each bus section, phase-to-phase and each phase-to-ground for a period of one minute at 2500 VDC.
   2. After successful completion of insulation resistance test, perform an overpotential test on each bus section, each phase-to-ground for a period of one minute at manufacturer's recommended voltage.

3. Inspect all mechanical and electrical interlocks for proper operation.
4. Perform insulation resistance test on all control wiring at 1000 VDC after disconnecting devices.

C. The manufacturer shall supply test results to confirm that the switchgear assembly design has been tested to substantiate conformance with the applicable ANSI and NEMA Standards. The tests shall verify not only the performance of the switch or integrated switch and relay, but also the suitability of the enclosure venting, rigidity and bus bracing. In addition, the switchgear assembly shall be factory tested in accordance with all applicable ANSI Standards and the Contract Documents.

D. Perform any other tests recommended by the equipment manufacturer.

3.3 MANUFACTURER'S SERVICES

A. A factory trained representative shall be provided for installation supervision, start-up and test services and operation and maintenance personnel training services. Manufacturer's representative shall test operate the system in the presence of the ENGINEER and verify that the medium-voltage switches conform to requirements. Representative shall revisit the job site as often as necessary until all trouble is corrected and the installation is entirely satisfactory.

B. All costs, including travel, lodging, meals and incidentals, shall be considered as included in CONTRACTOR’S bid price.

++ END OF SECTION ++