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SECTION 26 05 00
COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.01 SUMMARY

- A. Intent of this Division's Specifications and Drawings is to provide a complete and workable facility, with complete systems as required by applicable codes, as indicated, and as specified.
- B. Provide complete and workable facility with complete systems that comply with the requirements of the state codes, local codes, and other authorities having jurisdiction. Include design, labor and materials required to install, test and place into operation the systems as called for in the Contract Documents and according to applicable codes and regulations.
- C. Specifications and the accompanying Drawings are complementary and what is called for by one is as binding as if called for by both.
- D. Follow Drawings as closely as is practical to do so and install additional bends, offsets and elbows where required by local conditions, and without additional cost to the Owner. Significant deviations from the routing shown on the drawings is subject for approval prior to installation.
- E. Work installed contrary to Drawings and Specifications is subject to change as directed by the Owner and no extra compensation will be allowed for making those changes.

1.02 REFERENCES

- A. Codes and Standards:
 - 1. Comply with applicable sections of the most recent editions and addenda of following.
 - 2. Codes include latest adopted editions, including current amendments, supplements and local jurisdiction requirements in effect as of the date of the Contract Documents, of/from:
 - a. IBC - International Building Code
 - b. NEC/NFPA 70 - National Electrical Code
 - c. ANSI/IEEE C2 - National Electrical Safety Code
 - d. ANSI - American National Standards Institute
 - e. NEMA - National Electrical Manufacturers Association
 - f. NFPA - National Fire Protection Association
 - g. NECA - National Electrical Contractor Association
 - h. NETA - National Electrical Testing Association
 - i. IEEE - Institute of Electrical and Electronic Engineers
 - j. UL - Underwriters Laboratories
 - 3. State of Washington:
 - a. IFC - International Fire Code
 - b. WAC - Washington Administrative Code
 - c. WSEC - Washington State Energy Code

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination
 - 1. Review Drawings of other trades and Owner provided equipment to avoid conflicts.
 - 2. Report potential conflicts to Owner, provide resolution prior to rough-in.
 - 3. Verify physical dimensions and access requirements of equipment to fit the space available.
 - 4. Arrange raceways, wiring, and equipment to permit ready access to switches and control components.
 - a. Keep doors and access panels clear.
 - 5. Coordinate electrical services with the appropriate serving utility.
 - a. No additional compensation will be allowed to the Contractor for connection fees or additional work or equipment required by the serving utility, but not covered in the Drawings or Specifications.

- B. Permits
 - 1. Obtain permits and inspections for the installation of work and pay charges required. Deliver certificates of inspection issued by authorities to the Owner.
- C. Change Orders
 - 1. Supplemental cost proposals by the Contractor accompanied with a complete itemized breakdown of labor and materials. Separate and allocate labor for each item of work.

1.04 SUBMITTALS

- A. Product Data:
 - 1. General:
 - a. Submit product data in PDF format for the equipment in all division 26 specifications for review.
 - b. Include, as part of the submittal, a copy of the specification with each section notated as either Complying, Deviating, or Exception taken with explanations. Failure to include will void review automatically.
 - 2. Include for each item as a minimum:
 - a. Product Data: Provide manufacturer's standard catalog pages and data sheets, including detailed information on materials, construction, ratings, listings, and available sizes, and configurations.
 - b. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
 - c. Clearly mark and label in each submittal, the piece of equipment provided.
 - 3. Duct-Bank Coordination Drawings: show duct profiles and coordination with other utilities and underground structures.
 - a. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
 - b. Sign and seal drawings by a qualified professional engineer licensed by the State of Washington.

1.05 CLOSEOUT SUBMITTALS

- A. Assemble complete submittal package for Division 26 equipment into a single submittal.
- B. Submit manufacturer's operation and maintenance instruction manuals and parts lists.
- C. Submit when the work is substantially complete.
- D. Provide complete record drawings with notations reflecting the as-built conditions.

1.06 QUALITY ASSURANCE

- A. Regulatory Requirements
 - 1. General:
 - a. Conform work and materials to requirements of the local, State, and Federal authorities having jurisdiction and other applicable laws and regulations.
 - b. Execute work in strict accordance with the best practices of the trades in a thorough, substantial, skillful and well-executed manner by competent workers. Provide a competent, experienced full-time Superintendent who is authorized to make decisions on behalf of the Contractor.
- B. Alignment
 - 1. Install panels, cabinets, and equipment level and true. Provide housekeeping pads and curbs accounting for floor or roof slope.
 - 2. Install distribution equipment and electrical enclosures fitted neatly, without gaps, openings, or distortion.
 - a. Properly and neatly, close unused openings with approved devices.
 - b. Fit surface panels, devices, and outlets with neat, appropriate, trims, plates, or covers without overhanging edges, protruding corners, or raw edges.

- C. Materials and Equipment:
 - 1. Where two or more units of the same class of equipment are furnished, use products of the same manufacturer. Component parts of the entire system need not be products of same manufacturer.
 - 2. Equipment scheduled by performance or model number is considered as the basis of the design. If other specified manufacturer's equipment is provided in lieu of the basis of design equipment the Contractor is responsible for changes and costs which may be necessary to accommodate this equipment.
- D. Cutting and Patching:
 - 1. Provide cutting, patching, and repairing for the proper installation and completion of the work specified in this Division.
 - 2. Fill holes which are cut oversize so that a tight fit is obtained around the sleeves passing through.
 - 3. New or existing work cut or damaged will be restored to its original condition. Where alterations disturb lawns, paving, walks, etc., the surfaces will be repaired, refinished, and left in condition existing prior to commencement of work.
- E. Visibly damaged goods are to be returned to the supplier and replaced at no additional cost to the Owner.
- F. Contractor is responsible for the coordination and installation of work specified in division 26.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Assume custody and responsibility for the items upon delivery and determining that the contents are complete and in satisfactory condition for installation.
- B. The Contractor is responsible for handling and control of equipment and liable for material loss due to delivery and storage problems.
- C. Materials and equipment delivered and placed in storage will be stored with protection from the weather, humidity, and temperature variation, dirt, and dust or other contaminants.

1.08 SITE CONDITIONS

- A. Coordinate shutdown and start-up of existing, temporary, and new systems and utilities. Notify Owner, City, and Utility Company.

1.09 WARRANTY

- A. Provide a written guarantee covering the work of this Division (for a period of one calendar year from the date of acceptance by the Owner) as required by the General Conditions.
- B. Provide manufacturer's written warranties for material and equipment furnished under this Division insuring parts and labor for a period of one year from the date of Owner acceptance of Work of this Division.
- C. Correct warranty items promptly upon notification.

1.10 UNINTERRUPTED SERVICE

- A. Maintain electrical, signal and communication services to all functioning portions of the building throughout construction.
- B. Pre-arrange with Owner outages necessary for new construction.

1.11 DEMOLITION AND SALVAGE

- A. General:
 - 1. Where affected by work, remove or relocate equipment, services, and systems encountered during the course of the remodel/construction work to a safe location that will be undisrupted by further construction.
- B. Salvage and Disposal:

1. Removed materials, not containing hazardous waste, not scheduled for reuse are the property of the Contractor for removal from the site, except for those items specifically indicated on the Drawings for salvage or reuse.
2. Neatly store salvaged items at one location at the site where directed by the Owner's Representative.

1.12 COMPLETION AND TESTING

- A. Upon completion and in the presence of the Owner or its representative, test systems to show that installed equipment operates as designed and specified, free of faults and unintentional grounds.
- B. Engage a journeyman electrician with required tools to conduct equipment tests. Arrange to have the equipment factory representative present for those tests where the manufacturer's warranty could be impacted by the absence of a factory representative.
- C. Provide a written record of performance tests and submit with operation and maintenance data.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

- A. Do not use products for applications other than as permitted by NFPA 70 and product listing.
- B. Only provide products listed, classified, and labeled as suitable for the purpose intended.

2.02 CONDUCTORS AND CABLES

- A. Provide single conductor building wire installed in suitable raceway unless otherwise indicated, permitted, or required.
 1. Insulation - 600V, type THHN/THWN or THHN/THWN-2
 2. Manufacturers:
 - a. General Cable
 - b. Okonite
 - c. Cerro Wire LLC
 - d. Southwire
- B. Comply with NEMA WC 70, UL 83, UL 44 as required.
- C. Provide copper conductors except where aluminum conductors are specifically indicated or permitted for substitution and approved by the Engineer or Owner.
 1. If aluminum conductors are used, provide voltage drop and ampacity calculations
- D. Conductor Construction
 1. Size 10 AWG and smaller shall be solid.
 2. Size 8 AWG and larger shall be stranded.
- E. Photovoltaic Wire
 1. Sunlight-resistant, single-conductor, stranded, insulated photovoltaic wire listed and labeled as complying with UL 4703; specifically designed for interconnection wiring of photovoltaic power systems in accordance with NFPA 70.
 2. Insulation voltage rating as required for photovoltaic power system voltage.
- F. Wiring Connectors shall be appropriate for the application, suitable for use with the conductors to be connected, and listed as complying with UL 486A-486B or UL 486C as applicable.
 1. For splicing and tapping conductors:
 - a. Size 8 AWG and smaller use twist-on insulated spring connectors
 - b. Size 6 AWG and larger use mechanical or compression connectors.
 2. For terminating conductors
 - a. Size 10 AWG and smaller use crimped terminals
 - b. Size 8 AWG and larger use mechanical or compression connectors
 3. Do not use insulation-piercing or insulation-displacement connectors designed for use with conductors without stripping insulation.

- G. Perform insulation resistance test for conductors 100A and larger, after installation and prior to termination.
 - 1. Tests to be performed, record and maintain the results in tabular form, clearly identify each conductor tested.
 - 2. Correct deficiencies and replace damaged or defective conductors and cables.

2.03 GROUNDING AND BONDING

- A. Provide all required components, conductors, connectors, conduit, boxes, fittings, supports, accessories, etc. as necessary for a complete grounding and bonding system.
 - 1. Use bare copper conductors where installed underground in direct contact with earth, otherwise use insulated copper conductors.
- B. Where conductor size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
- C. Grounding Electrode System:
 - 1. Provide connection to required and supplemental grounding electrodes indicated to form grounding electrode system.
 - a. Provide continuous grounding electrode conductors without splice or joint.
 - b. Install grounding electrode conductors in raceway where exposed to physical damage. Bond grounding electrode conductor to metallic raceways at each end with bonding jumper.
 - 2. Provide connection to concrete-encased electrode consisting of not less than 20 feet of either steel reinforcing bars or bare copper conductor not smaller than 4 AWG embedded within concrete foundation or footing that is in direct contact with earth in accordance with NFPA 70.
 - 3. Ground rod electrodes to comply with NEMA GR 1 and shall be 5/8" diameter by 10 ft.
 - a. Space electrodes not less than 10 feet from each other and other ground electrode.
 - b. Where location is not indicated, locate as near as possible to electrical service entrance; where possible, locate in softscape (uncovered) area.
 - c. Provide open-bottom round or rectangular ground access well with access cover for first connected electrode.
 - 4. System resistance shall not be greater than 5 ohms to ground, when tested according to IEEE 81 "fall of potential" method.
- D. Use connectors appropriate for the application and suitable for the conductors and items to be connected; listed and labeled as complying with UL 467.
 - 1. For underground and other inaccessible locations, use exothermic welded connectors
 - 2. For accessible locations use mechanical or compression connectors
 - 3. Manufacturers
 - a. Burndy LLC
 - b. UltraWeld
 - c. Thomas & Betts
 - d. Cadweld
- E. Where the source of the separately derived system is located outside the building or structure supplied, provide connection to grounding electrode at source in accordance with NFPA 70
 - 1. Provide system bonding jumper to connect system grounded conductor to equipment ground bus. Make connection at same location as grounding electrode conductor connection. Do not make any other connections between neutral (grounded) conductors and ground on load side of separately derived system disconnect.
- F. Provide bonding for equipment grounding conductors, equipment ground busses, metallic equipment enclosures, metallic raceways and boxes, device grounding terminals, and other normally non-current-carrying conductive materials enclosing electrical conductors/equipment or likely to become energized as indicated and in accordance with NFPA 70

- G. Where circuit conductor sizes are increased for voltage drop, increase size of equipment grounding conductor proportionally in accordance with NFPA 70.

2.04 HANGERS AND SUPPORTS

- A. Provide required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for complete installation of electrical work.
- B. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for load to be supported. Include consideration for vibration, equipment operation, and shock loads where applicable.
- C. Do not use wire, chain, perforated pipe strap, or wood for permanent supports.
- D. Steel Components: Use corrosion-resistant materials suitable for environment where installed.
- E. Use one or two hole type steel or malleable iron conduit straps
- F. Use boted type conduit clamps
- G. Use factory-fabricated, continuous-slot, 1-5/8" wide by 13/16" high, galvanized steel channel/strut and associated fittings, accessories, and hardware required for field assembly of supports complying with MFMA-4 and UL-5B.
- H. Provide anchor and fastener types as indicated for specified applications
 - 1. Concrete: Use preset concrete inserts, expansion anchors, or screw anchors.
 - 2. Steel: Use beam clamps, machine bolts, or welded threaded studs.
 - 3. Preset Concrete Inserts: Continuous metal channel/strut and spot inserts specifically designed to be cast in concrete
 - 4. Plastic and lead, powder-actuated, and hammer-driven fasteners are not permitted.

2.05 CONDUIT AND FITTINGS

- A. Where installed underground or imbedded in within concrete, use galvanized steel rigid metal (RMC) or rigid polyvinyl (PVC)
 - 1. Where rigid PVC conduit is provided, transition to galvanized steel rigid metal conduit where emerging from underground or concrete.
 - 2. Where rigid PVC conduit is larger than 2 inch trade size is provided, use galvanized steel rigid metal conduit elbows for bends.
- B. Where installed in an exposed, exterior location, use galvanized steel RMC.
- C. Where installed in a concealed, exterior location, use galvanized steel RMC, intermediate metal (IMC), or electrical metallic tubing (EMT) conduit.
- D. Liquidtight flexible metal conduit with a minimum length of 3 ft. and a maximum length of 6 ft. is permitted to be used when connecting to transformers.
- E. Minimum conduit size is 3/4" trade size.
- F. Manufacturers
 - 1. Allied Tube & Conduit
 - 2. Republic Conduit
 - 3. Wheatland Tube Company
- G. Conduit Fittings
 - 1. Fitting material to be compatible with conduit to be connected per manufacturer.
 - 2. Where installed in an exterior location, fittings to be listed for use in wet locations.
 - 3. For RMC, IMC conduits, use threaded type fittings only
 - 4. For EMT conduits, use compression/gland or set-screw type fittings only
- H. Conduit and fittings to comply with the following standards
 - 1. RMC conduit - ANSI C80.1 and UL 6; fittings - NEMA FB 1 and UL 514B
 - 2. Rigid PVC - NEMA TC 2 and UL 651, Schedule 40; fittings - NEMA TC 3 and UL 651
 - 3. IMC conduit - ANSI C80.6 and UL 1242; fittings - NEMA FB 1, UL 514B, and UL 1242
 - 4. EMT conduit - ANSI C80.3 and UL 797; fittings - NEMA FB 1 and UL 514B

- 5. Liquidtight flexible metallic conduit - UL 360; fittings - NEMA FB 1 and UL 514B
- I. Corrosion Protection Tape: PVC-based, minimum thickness of 20 mil, 0.020 inch
- J. Conduit Joint Compound: Corrosion-resistant, electrically conductive compound listed as complying with UL 2419; suitable for use with conduit to be installed.
- K. Solvent Cement for PVC Conduit and Fittings: As recommended by manufacturer of conduit and fittings to be installed.
- L. Pull Strings: Use nylon or polyester tape with average breaking strength of not less than 1,250 lbf

2.06 BOXES

- A. Provide boxes, fittings, supports, and accessories required for a complete raceway system and to accommodate devices and equipment to be installed.
- B. Outlet and Device Boxes Up to 100 cubic inches, Including Those Used as Junction and Pull Boxes:
 - 1. For dry locations use sheet-steel boxes complying with NEMA OS 1 and UL 514A.
 - 2. For damp or wet locations use cast iron boxes or cast aluminum boxes complying with NEMA FB 1 and UL 514A; furnish with compatible weatherproof gasketed covers.
 - 3. Where exposed rigid PVC conduit is used, use nonmetallic boxes complying with NEMA OS 2 and UL 514C.
 - 4. Minimum size for wiring devices to be 4" square by 1-1/2" deep.
- C. Cabinets and Enclosures, Including Junction and Pull Boxes Larger Than 100 cubic inches:
 - 1. Comply with NEMA EN 10250, UL 50, and UL 50E.
 - 2. For outdoor locations use NEMA Type 3R, manufacturer's standard grey painted steel.
 - 3. For junction and pull boxes provide screw-cover or hinged-cover enclosures.
- D. Underground/In-grade Junction Boxes
 - 1. In-ground, open bottom boxes with flush, non-skid covers with legend indicating type of service and stainless steel tamper resistant cover bolts, sized as indicated on drawings.
 - 2. Depth as required to extend below frost line line, but not less than 12".
 - 3. For sidewalks and landscaped areas subject only to occasional nondeliberate vehicular traffic use polymer concrete enclosures with minimum SCTE 77 Tier 8 load rating.
 - 4. For parking lots, in areas subject only to occasional nondeliberate vehicular traffic use polymer concrete enclosures, with minimum SCTE 77 Tier 15 load rating.
 - 5. Combination fiberglass/polymer concrete boxes/enclosures are acceptable.

2.07 UNDERGROUND DUCTS, RACEWAYS, AND VAULTS

- A. Size ducts and conduits not less than 4" trade size unless shown otherwise on the drawings,
- B. Manufactured bends shall be not less than 36-inches in radius for conduits 4-inches in diameter or larger.
- C. Use factory-fabricated rigid PVC vertical and horizontal interlocking spacers, sized for type and sizes of conduits used, and selected to provide minimum of 3-inches separation between ducts while supporting ducts during concreting or backfilling.
- D. Use conduit expansion/deflection fittings in embedded runs rated for outdoor use, buried underground, or embedded in concrete that allow axial expansion or contraction up to 3/4-inch and angular misalignment of the axes of the coupled runs in any direction to 30 degrees. Inner sleeves maintain constant inside diameter in any position and provide smooth insulated wireway for protection of wire insulation.
- E. Precast Concrete Vaults:
 - 1. Precast concrete, minimum 4,000 psi strength at 28 days, with reinforcing and cover designed for AASHTO loading of H-20 and conforming to ASTM C 478.
 - 2. Wall thickness 3-inches minimum. Necking and shaft 36-inch minimum clear opening.

3. Precast structures designed in accordance with AASHTO Specification for Highway Bridges. Design concrete and reinforcing in accordance with ACI 318.
4. Design tops and walls of structures for AASHTO H-20 highway loading, with 30 percent loading added for impact.
5. Design walls to withstand soil pressures, taking into consideration the soil to be encountered and groundwater level present at the site.
6. Assume ground water level is at ground surface unless a lower water table is indicated in the boring logs. Precast vaults designed and constructed not to float.
7. Manhole Cover and Frame: Class 30B grey cast iron per ASTM A 48 with machine-finished, flat, bearing surfaces.
8. Frame: Solid cast ductile iron with a 36-inch round opening. Provide cover with holes for lifting and shall have minimum 2-inch high factory label ELECTRIC or as appropriate.

2.08 VIBRATION AND SEISMIC

- A. Provide vibration isolation systems to reduce vibration transmission to supporting structure from vibration-producing electrical equipment and/or electrical connections to vibration-isolated equipment.
 1. Select vibration isolators to provide required static deflection and uniform deflection based on distributed operating weight of actual installed equipment.
 2. Select seismic type vibration isolators to comply with seismic design requirements, including conditions of equipment seismic certification where applicable.
 3. Select vibration isolators for outdoor equipment to comply with wind design requirements.
 4. Select vibration-isolated equipment support bases and associated vibration isolators to provide minimum 2-inch operating clearance beneath base unless otherwise indicated.
 5. Vibration isolators to be made of oil, ozone, and oxidant resistant materials.
- B. For pad-mounted transformers use seismic type resilient material isolator mounts or seismic type restrained spring isolators with a minimum static deflection of 1/4".
- C. Design and provide electrical component restraints, supports, and attachments suitable for seismic loads determined in accordance with applicable codes, as well as gravity and operating loads and other structural design considerations of the installed location. Consider wind loads for outdoor electrical components.
 1. Seismic restraint capacities to be verified by a Nationally Recognized Testing Laboratory (NRTL) or certified by an independent third-party registered professional engineer acceptable to authorities having jurisdiction.
 2. Except where otherwise restricted, use of either cable or rigid restraints is permitted.
- D. Seismic attachments to be bolted, welded, or otherwise positively fastened without consideration of frictional resistance produced by the effects of gravity.
 1. Increase size of concrete pads as required to comply with anchor requirements.
- E. Include provisions to prevent seismic impact between electrical components and other structural or nonstructural components.
- F. Include provisions such that failure of a component, either essential or nonessential, does not cause the failure of an essential component.
- G. Use suitable fittings or flexible connections to accommodate relative displacements at connections between components, including distributed systems (e.g., conduit); do not exceed load limits for equipment utility connections.
 1. Relative displacements between component supports attached to dissimilar parts of structure that may move differently during an earthquake.

2.09 IDENTIFICATION FOR ELECTRICAL EQUIPMENT

- A. Use identification nameplate to identify each piece of electrical distribution and control equipment and associated sections, compartments, and components.
 1. For outdoor locations use plastic, stainless steel, or aluminum nameplates suitable for exterior use.

- B. For switchboards and panelboards identify ampere rating, voltage, phase, power source and circuit number, and available fault.
- C. For enclosed switches and breakers identify voltage, phase, power source and circuit number, and load(s) served (include location when not within sight of equipment), and available fault.
- D. For enclosed contactors identify ampere rating, voltage, phase, coil voltage, configuration e.g., E.O.E.H. (electrically operated, electrically held) or E.O.M.H. (electrically operated, mechanically held), and load(s) served.
- E. For meters identify ampere rating, voltage, phase, and load(s) metered.
- F. Use an identification nameplate to identify each service disconnecting means, include all other services, feeders, and branch circuits supplying
- G. Use wire and cable markers to identify circuit number or other designation indicated for power, control, and instrumentation conductors and cables at the following locations:
 - 1. At each source and load connection.
 - 2. Within boxes when more than one circuit is present.
 - 3. Within equipment enclosures when conductors and cables enter or leave the enclosure.
- H. Use underground, non-detectable, polyethylene warning tape to identify direct buried cables.
- I. Use identification labels, or plastic marker tags to identify circuits enclosed for accessible conduits at wall penetrations when source is not within sight.
- J. Use identification labels, handwritten text using indelible marker, or plastic marker tags to identify spare conduits at each end.

PART 3 EXECUTION

3.01 EXAMINATION AND PREPERATION

- A. Verify condition are satisfactory for installation prior to starting work.
- B. Clean raceways thoroughly to remove foreign materials before installing conductors.

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Conductors and Conduit:
 - 1. Provide complete electrical connections for items of equipment requiring such connections, including incidental wiring, materials, devices, and labor necessary for a finished working installation.
 - 2. Verify location and method for connecting to each item of equipment prior to roughing-in.
 - 3. Check amperage, maximum overcurrent protection, voltage, phase, and similar attributes of each item of equipment before rough in and connection.
 - 4. Conduit routing shown on drawings is diagrammatic only.
 - 5. Splices and taps to be made only in accessible boxes.
 - 6. Tape ends of conductors and cables to prevent infiltration of moisture and other contaminants.
 - 7. Pull conductors and cables together into raceway at same time.
 - 8. Do not pull wire in until bushings are installed and raceways terminations are completed.
 - 9. Do not pull wire into conduit embedded in concrete until after the concrete poured and forms stripped.
 - 10. Do not damage conductors and cables or exceed manufacturer's recommended maximum pulling tension and sidewall pressure.
 - 11. Use suitable wire pulling lubricant where necessary, except when lubricant is not recommended by the manufacturer.
 - 12. Parallel runs of conductors to be equal length and terminated in the same manner.
 - 13. Neatly train and bundle conductors inside boxes, wireways, panelboards and other equipment enclosures.

14. Insulate ends of spare conductors using vinyl insulating electrical tape.
 15. Install firestopping to preserve fire resistance rating of partitions and other elements
- D. Conduit:
1. Conduit routing shown on drawings is diagrammatic only.
 2. Arrange conduit to provide no more than 150 feet between pull points.
 3. Secure and support conduits in accordance with NFPA 70 using suitable supports and methods.
 4. Use approved zinc-rich paint or conduit joint compound on field-cut threads of galvanized steel conduits prior to making connections.
 5. Use suitable adapters where required to transition from one type of conduit to another.
 6. Provide drip loops for liquidtight flexible conduit connections to prevent drainage of liquid into connectors.
 7. Terminate threaded conduits in boxes and enclosures using threaded hubs or double lock nuts.
 8. Provide insulating bushings, insulated throats, or listed metal fittings with smooth, rounded edges at conduit terminations to protect conductors.
 9. Provide sleeves for penetrations as indicated or as required to facilitate installation.
 10. Provide trenching and backfilling with a minimum cover of 24" for underground conduit installations.
 11. Provide foam conduit sealant to prevent entry of moisture at building penetrations.
 12. Provide pull string in each empty conduit and in conduits where conductors and cables are to be installed by others. Leave minimum slack of 12 inches at each end.
- E. Boxes:
1. Unless otherwise indicated, boxes may be surface-mounted where exposed conduits are indicated or permitted.
 2. Locate boxes to be accessible.
 3. Locate junction and pull boxes as indicated, as required to facilitate installation of conductors, and to limit conduit length and/or number of bends between pulling points.
 4. Close unused box openings.
 5. Underground Boxes/Enclosures:
 - a. Install enclosure on gravel base, minimum 6 inches deep.
 - b. Flush-mount enclosures located in concrete or paved areas.
 - c. Mount enclosures located in landscaped areas with top at 1" above finished grade.
- F. Equipment Support:
1. Use metal, fabricated supports or supports assembled from metal channel/strut to support equipment as required.
 2. Unless otherwise indicated, mount floor-mounted equipment on properly sized concrete pad 3 inches in height.
 3. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.
- G. Grounding and Bonding:
1. Unless otherwise indicated, install ground rod electrodes vertically.
 2. Unless otherwise indicated, install with top of rod 6 inches below finished grade.
 3. Remove nonconductive paint, enamel, or similar coating at threads, contact points, and contact surfaces.
 4. Exothermic Welds: Make connections using molds and weld material suitable for the items to be connected in accordance with manufacturer's recommendations.
 5. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.
 6. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.

3.03 PROTECTION

- A. Protect electrical work and equipment installed under this Division against damage by other trades, weather conditions, or any other causes.
 - 1. Equipment found damaged or in other than new condition will be rejected as defective.

END OF SECTION 26 05 00

**SECTION 26 05 73
POWER SYSTEM STUDIES**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Short-circuit study.
- B. Protective device coordination study.
- C. Arc flash and shock risk assessment.
 - 1. Includes arc flash hazard warning labels.
- D. Criteria for the selection and adjustment of equipment and associated protective devices not specified in this section, as determined by studies to be performed.

1.02 REFERENCE STANDARDS

- A. ANSI Z535.4 - American National Standard for Product Safety Signs and Labels.
- B. IEEE 141 - IEEE Recommended Practice for Electric Power Distribution for Industrial Plants.
- C. IEEE 242 - IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.
- D. IEEE 399 - IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis.
- E. IEEE 551 - IEEE Recommended Practice for Calculating Short-Circuit Currents in Industrial and Commercial Power Systems.
- F. IEEE 1584 - IEEE Guide for Performing Arc-Flash Hazard Calculations.
- G. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems.
- H. NFPA 70 - National Electrical Code.
- I. NFPA 70E - Standard for Electrical Safety in the Workplace.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Existing Installations: Coordinate with equipment manufacturer(s) to obtain data necessary for completion of studies.
 - 2. Coordinate work to provide equipment and associated protective devices complying with criteria for selection and adjustment, as determined by studies to be performed.
 - 3. Notify Engineer of conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Pre-Study Meeting: Conduct meeting with Owner to discuss system operating modes and conditions to be considered in studies.
- C. Sequencing:
 - 1. Submit study reports prior to or concurrent with product submittals.
 - 2. Do not order equipment until matching study reports and product submittals have both been evaluated by Engineer.
 - 3. Verify naming convention for equipment identification prior to creation of final drawings, reports, and arc flash hazard warning labels (where applicable).
- D. Scheduling:
 - 1. Arrange access to existing facility for data collection with Owner.

1.04 SUBMITTALS

- A. See Section 26 05 00 - Common Work Results for Electrical, for submittal procedures.
- B. Study preparer's qualifications.

- C. Field testing agency's qualifications.
- D. Study reports, stamped or sealed and signed by study preparer.
- E. Product Data: In addition to submittal requirements specified in other sections, include manufacturer's standard catalog pages and data sheets for equipment and protective devices indicating information relevant to studies.
 - 1. Include characteristic time-current trip curves for protective devices.
 - 2. Include impedance data for busway.
 - 3. Clearly indicate whether proposed short circuit current ratings are fully rated or, where acceptable, series rated systems.
 - 4. Include documentation of listed series ratings upon request.
 - 5. Identify modifications made in accordance with studies that:
 - a. Can be made at no additional cost to Owner.
 - b. As submitted will involve a change to the contract sum.
- F. Site-specific arc flash hazard warning labels.
- G. Field quality control reports.
- H. Certification that field adjustable protective devices have been set in accordance with requirements of studies.
- I. Project Record Documents: Revise studies as required to reflect as-built conditions.
 - 1. Include hard copies with operation and maintenance data submittals.
 - 2. Include computer software files used to prepare studies with file name(s) cross-referenced to specific pieces of equipment and systems.

1.05 POWER SYSTEM STUDIES

- A. Scope of Studies:
 - 1. Perform analysis of both new and directly affected existing portions of electrical distribution systems as indicated on drawings.
 - 2. Except where study descriptions below indicate exclusions, analyze system at each bus from primary protective devices of utility source down to each piece of equipment involved, including parts of system affecting calculations being performed (e.g. fault current contribution from motors).
 - 3. Include in analysis alternate sources and operating modes (including known future configurations) to determine worst case conditions.
 - a. Known Operating Modes:
 - 1) Utility as source.
 - 2) Microgrid and PV as source.
 - 3) Maintenance settings.
- B. General Study Requirements:
 - 1. Comply with NFPA 70.
 - 2. Perform studies utilizing computer software complying with specified requirements; manual calculations are not permitted.
- C. Data Collection:
 - 1. Compile information on project-specific characteristics of actual installed equipment, protective devices, feeders, etc. as necessary to develop single-line diagram of electrical distribution system and associated input data for use in system modeling.
 - a. Utility Source Data: Include primary voltage, maximum and minimum three-phase and line-to-ground fault currents, impedance, X/R ratio, and primary protective device information.
 - 1) Obtain up-to-date information from Utility Company.
 - b. Generators: Include manufacturer/model, kW and voltage ratings, and impedance.

- c. Motors: Include manufacturer/model, type (e.g. induction, synchronous), horsepower rating, voltage rating, full load amps, and locked rotor current or NEMA MG 00001 code letter designation.
- d. Transformers: Include primary and secondary voltage ratings, kVA rating, winding configuration, percent impedance, and X/R ratio.
- e. Protective Devices:
 - 1) Circuit Breakers: Include manufacturer/model, type (e.g. thermal magnetic, electronic trip), frame size, trip rating, voltage rating, interrupting rating, available field-adjustable trip response settings, and features (e.g. zone selective interlocking).
 - 2) Fuses: Include manufacturer/model, type/class (e.g. Class J), size/rating, and speed (e.g. time delay, fast acting).
- f. Protective Relays: Include manufacturer/model, type, settings, current/potential transformer ratio, and associated protective device.
- g. Conductors: Include feeder size, material (e.g. copper, aluminum), insulation type, voltage rating, number per phase, raceway type, and actual length.
- 2. Existing Installations:
 - a. Collect data on existing electrical distribution system necessary for completion of studies, including field verification of available existing data (e.g. construction documents, previous studies). Include actual settings for field-adjustable devices.
- D. Short-Circuit Study:
 - 1. Comply with IEEE 551 and applicable portions of IEEE 141, IEEE 242, and IEEE 399.
 - 2. For purposes of determining equipment short circuit current ratings, consider conditions that may result in maximum available fault current, including but not limited to:
 - a. Maximum utility fault currents.
 - b. Maximum motor contribution.
 - c. Known operating modes.
 - 3. For each bus location, calculate the maximum available three-phase bolted symmetrical and asymmetrical fault currents. For grounded systems, also calculate the maximum available line-to-ground bolted fault currents.
- E. Protective Device Coordination Study:
 - 1. Comply with applicable portions of IEEE 242 and IEEE 399.
 - 2. Analyze alternate scenarios considering known operating modes (e.g. utility as source, generator as source, utility/generator in parallel, bus tie breaker open/close positions).
 - 3. Analyze protective devices and associated settings for suitable margins between time-current curves to provide adequate protection for equipment and conductors while achieving full selective coordination.
- F. Arc Flash and Shock Risk Assessment:
 - 1. Comply with NFPA 70E.
 - 2. Perform incident energy and arc flash boundary calculations in accordance with IEEE 1584 (as referenced in NFPA 70E Annex D), where applicable.
 - a. Where reasonable, study preparer may assume a maximum clearing time of two seconds in accordance with IEEE 1584, provided that the conditions are such that a worker's egress from an arc flash event would not be inhibited.
 - 3. Analyze alternate scenarios considering conditions that may result in maximum incident energy, including but not limited to:
 - a. Maximum and minimum utility fault currents.
 - b. Maximum and minimum motor contribution.
 - c. Known operating modes.
- G. Study Reports:
 - 1. General Requirements:
 - a. Identify date of study and study preparer.

- b. Identify study methodology and software product(s) used.
 - c. Identify scope of studies, assumptions made, implications of possible alternate scenarios, and exclusions from studies.
 - d. Identify base used for per unit values.
 - e. Include single-line diagram and associated input data used for studies; identify buses on single-line diagram as referenced in reports, and indicate bus voltage.
 - f. Include conclusions and recommendations.
2. Short-Circuit Study:
- a. For each scenario, identify at each bus location:
 - 1) Calculated maximum available symmetrical and asymmetrical fault currents (both three-phase and line-to-ground where applicable).
 - 2) Fault point X/R ratio.
 - 3) Associated equipment short circuit current ratings.
 - b. Identify locations where the available fault current exceeds the equipment short circuit current rating, along with recommendations.
3. Protective Device Coordination Study:
- a. For each scenario, include time-current coordination curves plotted on log-log scale graphs.
 - b. For each graph include (where applicable):
 - 1) Partial single-line diagram identifying the portion of the system illustrated.
 - 2) Protective Devices: Time-current curves with applicable tolerance bands for each protective device in series back to the source, plotted up to the maximum available fault current at the associated bus.
 - 3) Conductors: Damage curves.
 - 4) Transformers: Inrush points and damage curves.
 - c. For each protective device, identify fixed and adjustable characteristics with available ranges and recommended settings.
 - 1) Circuit Breakers: Include long time pickup and delay, short time pickup and delay, and instantaneous pickup.
 - 2) Include ground fault pickup and delay.
 - 3) Include fuse ratings.
 - 4) Protective Relays: Include current/potential transformer ratios, tap, time dial, and instantaneous pickup.
 - d. Identify cases where either full selective coordination or adequate protection is not achieved, along with recommendations.
4. Arc Flash and Shock Risk Assessment:
- a. For the worst case for each scenario, identify at each bus location:
 - 1) Calculated incident energy and associated working distance.
 - 2) Calculated arc flash boundary.
 - 3) Bolted fault current.
 - 4) Arcing fault current.
 - 5) Clearing time.
 - 6) Arc gap distance.
 - b. For purposes of producing arc flash hazard warning labels, summarize the maximum incident energy and associated data reflecting the worst case condition of all scenarios at each bus location.
 - c. Include recommendations for reducing the incident energy at locations where the calculated maximum incident energy exceeds 8 calories per sq cm.

1.06 QUALITY ASSURANCE

- A. Study Preparer Qualifications: Professional electrical engineer licensed in the State in which the Project is located and with minimum five years experience in preparation of studies of similar type and complexity using specified computer software.
 - 1. Study preparer may be employed by manufacturer of electrical distribution equipment.

2. Study preparer may be employed by field testing agency.
- B. Field Testing Agency Qualifications: Independent testing organization specializing in testing, analysis, and maintenance of electrical systems with minimum five years experience; NETA Accredited Company.
 1. Field Supervisor: Certified electrical testing technician; NETA ETT Level III.
- C. Computer Software for Study Preparation: Use the latest edition of commercially available software utilizing specified methodologies.
 1. Products:
 - a. EasyPower LLC.
 - b. ETAP/Operation Technology, Inc.
 - c. Power Analytics Corporation.
 - d. SKM Systems Analysis, Inc.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Emerson
- B. Electrical Systems Analysis
- C. Qualified engineers of the switchgear manufacturer

2.02 ARC FLASH HAZARD WARNING LABELS

- A. Provide warning labels complying with ANSI Z535.4 to identify arc flash hazards for each work location analyzed by the arc flash and shock risk assessment.
 1. Materials: Comply with Section 26 05 00.26 05 53.
 2. Minimum Size: 4 by 6 inches.
 3. Legend: Provide custom legend in accordance with NFPA 70E based on equipment-specific data as determined by arc flash and shock risk assessment.
 - a. Include orange header that reads "WARNING" unless otherwise indicated.
 - b. Include the text "Arc Flash and Shock Hazard; Appropriate PPE Required" or approved equivalent.
 - c. Include the following information:
 - 1) Arc flash boundary.
 - 2) Available incident energy and corresponding working distance.
 - 3) Site-specific PPE (personnel protective equipment) requirements.
 - 4) Nominal system voltage.
 - 5) Limited approach boundary.
 - 6) Restricted approach boundary.
 - 7) Equipment identification.
 - 8) Study preparer, report reference, and date calculations were performed.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install arc flash warning labels in accordance with Section 26 05 00.26 05 53.

3.02 FIELD QUALITY CONTROL

- A. Provide the services of field testing agency or equipment manufacturer's representative to perform inspection, testing, and adjusting.
- B. Inspect and test in accordance with NETA ATS, except Section 4.
- C. Adjust equipment and protective devices for compliance with studies and recommended settings.
- D. Notify Owner of conflicts with or deviations from studies. Obtain direction before proceeding.

- E. Submit detailed reports indicating inspection and testing results, and final adjusted settings.

END OF SECTION 26 05 73

SECTION 26 08 00
COMMISSIONING FOR ELECTRICAL

PART 1 GENERAL

1.01 SUMMARY

- A. Commissioning is intended to achieve the following specific objectives; this section specifies the Contractor's responsibilities for commissioning:
 - 1. Verify that the work is installed in accordance with the Contract Documents and the manufacturer's recommendations and instructions, and that it receives adequate operational checkout prior to startup: Startup reports and Prefunctional Checklists executed by Contractor are utilized to achieve this.
 - 2. Verify and document that functional performance is in accordance with the Contract Documents: Functional Tests executed by Contractor are utilized to achieve this.
 - 3. Verify that operation and maintenance manuals submitted to Owner are complete: Detailed operation and maintenance (O&M) data submittals by Contractor are utilized to achieve this.
 - 4. Verify that the Owner's operating personnel are adequately trained: Formal training conducted by Contractor is utilized to achieve this.
- B. Commissioning, including Functional Tests, O&M documentation review, and training, is to occur after startup and initial checkout and be completed before Functional Completion[<>].

1.02 SUBMITTALS

- A. Make all submittals specified in this section, and elsewhere where indicated for commissioning purposes.
- B. Manufacturers' Instructions: Submit copies of all manufacturer-provided instructions that are shipped with the equipment as soon as the equipment is delivered.
- C. Startup Plans and Reports.
- D. Completed Prefunctional Checklists.
- E. Commissioning Issues Log:
 - 1. Construction observations.
 - 2. Supporting photographs.

PART 2 PRODUCTS

2.01 TEST EQUIPMENT

- A. Provide all standard testing equipment required to perform startup and initial checkout and required Functional Testing; unless otherwise noted such testing equipment will NOT become the property of Owner.
- B. Calibration Tolerances: Provide testing equipment of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified.
- C. Equipment-Specific Tools: Where special testing equipment, tools and instruments are specific to a piece of equipment, are only available from the vendor, and are required in order to accomplish startup or Functional Testing, provide such equipment, tools, and instruments as part of the work at no extra cost to Owner; such equipment, tools, and instruments are to become the property of Owner.

PART 3 EXECUTION

3.01 INSTALLATION, CHECK-OUT, START-UP AND PREFUNCTIONAL CHECKS

- A. Startup Plans: For each item of equipment and system for which the manufacturer provides a startup plan, submit the plan not less than 8 weeks prior to startup.
- B. Startup Reports: For each item of equipment and system for which the manufacturer provides a startup checklist (or startup plan or field checkout sheet), document compliance by submitting the completed startup checklist prior to startup, signed and dated by responsible entity.

- C. A Prefunctional Checklist is required to be filled out for each item of equipment or other assembly specified to be commissioned.
 - 1. No sampling of identical or near-identical items is allowed.
 - 2. These checklists do not replace manufacturers' recommended startup checklists, regardless of apparent redundancy.
 - 3. Prefunctional Checklist forms will not be complete until after award of the contract; the following types of information will be gathered via the completed Checklist forms:
 - a. Certification by installing contractor that the unit is properly installed, started up, and operating and ready for Functional Testing.
 - b. Manufacturer, model number, and relevant capacity information; list information "as specified," "as submitted," and "as installed."
 - c. Serial number of installed unit.
 - d. List of inspections to be conducted to document proper installation prior to startup and Functional Testing; these will be primarily static inspections and procedures; for equipment and systems may include normal manufacturer's start-up checklist items and minor testing.
 - 4. PEI (Samples) found at <http://www.peci.org/library/mcpgs.htm> indicate anticipated level of detail for Prefunctional Checklists.
- D. Contractor is responsible for filling out Prefunctional Checklists, after completion of installation and before startup.
- E. Deficiencies: Correct deficiencies and re-inspect or re-test, as applicable, at no extra cost to Owner.

3.02 FUNCTIONAL TESTING

- A. A Functional Test is required for each item of equipment, system, or other assembly specified to be commissioned, unless sampling of multiple identical or near-identical units is allowed by the final test procedures.
- B. Contractor is responsible for execution of required Functional Tests, after completion of Prefunctional Checklist and before closeout.
- C. Contractor is responsible for correction of deficiencies and re-testing at no extra cost to Owner; if a deficiency is not corrected and re-tested immediately.
 - 1. Deficiencies are any condition in the installation or function of a component, piece of equipment or system that is not in compliance with the Contract Documents or does not perform properly.
- D. PEI (Samples) found at <http://www.peci.org/library/mcpgs.htm> indicated anticipated level of detail for Functional Tests.
- E. Deferred Functional Tests: Some tests may need to be performed later, after substantial completion, due to partial occupancy, equipment, seasonal requirements, design or other site conditions; performance of these tests remains the Contractor's responsibility regardless of timing.
- F. Factory Tests: Contractor is responsible for coordinating testing of equipment at the factory by factory personnel, to ensure compliance with commissioning requirements.
- G. Field Tests By Others: Where Functional Tests are indicated as to be performed by others not subject to the Contract Documents, those tests are not subject to these commissioning requirements.

END OF SECTION 26 08 00

SECTION 26 22 00
LOW-VOLTAGE TRANSFORMERS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. General purpose transformers.

1.02 REFERENCE STANDARDS

- A. IEEE C57.94 - IEEE Recommended Practice for Installation, Application, Operation, and Maintenance of Dry-Type Distribution and Power Transformers.
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction.
- C. NECA 409 - Standard for Installing and Maintaining Dry-Type Transformers.
- D. NEMA ST 20 - Dry Type Transformers for General Applications.
- E. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems.
- F. NFPA 70 - National Electrical Code.

1.03 SUBMITTALS

- A. See Section 26 05 00 - Common Work Results for Electrical, for submittal procedures.
- B. Product Data: Include voltage, kVA, impedance, tap configurations, insulation system class and rated temperature rise, efficiency, sound level, enclosure ratings, outline and support point dimensions, weight, required clearances, service condition requirements, and installed features.
- C. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

PART 2 PRODUCTS

2.01 ISOLATION TRANSFORMER

- A. Description: Factory-assembled, dry type, self-cooled, ventilated, two winding transformers for 60 Hz operation designed and manufactured in accordance with NEMA ST 20 and listed, classified, and labeled as suitable for the purpose intended.
- B. General requirements
 - 1. Size, voltage, and phase as shown on the drawings.
 - 2. Class 200°C insulation system with 150°C average winding temperature rise.
 - 3. Continuous aluminum or copper windings with terminations brazed or welded.
 - 4. Two 2.5% full capacity primary taps both above and below rated voltage.
 - 5. NEMA type 3R enclosure with manufacturer's standard gray finish
 - 6. Basic Impulse Level: 10 kV.
- C. Manufacturer
 - 1. Powersmiths (Socomec)
- D. Core: High grade, non-aging silicon steel with high magnetic permeability and low hysteresis and eddy current losses. Keep magnetic flux densities substantially below saturation point, even at 10 percent primary overvoltage. Tightly clamp core laminations to prevent plate movement and maintain consistent pressure throughout core length.
- E. Impregnate core and coil assembly with non-hydroscopic thermo-setting varnish to effectively seal out moisture and other contaminants.
- F. Ground core and coil assembly to enclosure by means of a visible flexible copper grounding strap. Isolate core and coil from enclosure using vibration-absorbing mounts.

- G. Nameplate to include transformer connection data, ratings, wiring diagrams, and overload capacity based on rated winding temperature rise.
- H. Energy Efficiency: Comply with 10 CFR 431, Subpart K.
- I. Sound Levels: Standard sound levels complying with NEMA ST 20 standard sound levels.

2.02 SOURCE QUALITY CONTROL

- A. Factory test transformers according to NEMA ST 20.
- B. Sound Level Tests: Perform factory test designated in NEMA ST 20 as "design" test on each production unit.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Perform pre-installation tests and inspections on transformers per manufacturer's instructions and as specified in NECA 409. Correct deficiencies prior to installation.
- B. Verify conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Install transformers in accordance with NECA 409 and IEEE C57.94.
- D. Use flexible conduit for connections to transformer case. Make conduit connections to side panel of enclosure.
- E. Arrange equipment to provide minimum clearances as specified on transformer nameplate and in accordance with manufacturer's instructions and NFPA 70.
- F. Install transformers plumb and level.
- G. Unless otherwise indicated, mount floor-mounted transformers on properly sized 3" high concrete pad.
- H. Provide grounding and bonding per section 26 05 00.
- I. Identify and label transformer per section 26 05 00.

3.03 FIELD QUALITY CONTROL

- A. Inspect and test in accordance with NETA ATS, except Section 4.
- B. Perform inspections and tests listed in NETA ATS Sections 7.2.1.1 and 7.2.1.2. Tests and inspections listed as optional are not required.
 - 1. Perform turns ratio tests at all tap positions.

3.04 ADJUSTING

- A. Measure primary and secondary voltages and make appropriate tap adjustments.
- B. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

3.05 CLEANING

- A. Clean dirt and debris from transformer components according to manufacturer's instructions.
- B. Repair scratched or marred exterior surfaces to match original factory finish.

END OF SECTION 26 22 00

**SECTION 26 24 13
SWITCHBOARDS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Low-voltage (600 V and less) switchboards and associated accessories for service and distribution applications.
- B. Overcurrent protective devices for switchboards.

1.02 REFERENCE STANDARDS

- A. FS W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service.
- B. IEEE C57.13 - IEEE Standard Requirements for Instrument Transformers.
- C. NECA 1 - Standard for Good Workmanship in Electrical Construction.
- D. NECA 400 - Standard for Installing and Maintaining Switchboards.
- E. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
- F. NEMA PB 2 - Deadfront Distribution Switchboards.
- G. NEMA PB 2.1 - General Instructions for Proper Handling, Installation, Operation, and Maintenance of Deadfront Distribution Switchboards Rated 1000 Volts or Less.
- H. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems.
- I. NFPA 70 - National Electrical Code.
- J. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures.
- K. UL 891 - Switchboards.
- L. UL 1053 - Ground-Fault Sensing and Relaying Equipment.

1.03 SUBMITTALS

- A. See Section 26 05 00 - Common Work Results for Electrical, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for switchboards, enclosures, overcurrent protective devices, and other installed components and accessories.
 - 1. Include characteristic trip curves for each type and rating of overcurrent protective device upon request.
- C. Shop Drawings: Indicate dimensions, voltage, bus ampacities, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
 - 1. Include dimensioned plan and elevation views of switchboards with all required clearances indicated.
 - 2. Include wiring diagrams showing factory and field connections.
- D. Source Quality Control Test Reports: Include reports for tests designated in NEMA PB 2 as production (routine) tests.
- E. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- F. Field Quality Control Test Reports.
- G. Furnish two of each different enclosure keys to the Owner.

1.04 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.

- B. Maintain at project site a copy of each referenced document that prescribes execution requirements.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store switchboards in accordance with manufacturer's instructions, NECA 400, and NEMA PB 2.1.
- B. Store in a clean, dry space having a uniform temperature to prevent condensation (including outdoor switchboards, which are not weatherproof until completely and properly installed). Where necessary, provide temporary enclosure space heaters or temporary power for permanent factory-installed space heaters.
- C. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- D. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Switchboards:
 - 1. ABB.
 - 2. Eaton Corporation.
 - 3. Schneider Electric; Square D Products.
 - 4. Siemens Industry, Inc.

2.02 SWITCHBOARDS

- A. Provide switchboards consisting of required components, control power transformers, instrumentation and control wiring, accessories, etc. as necessary for a complete operating system.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Description: Dead-front switchboard assemblies complying with NEMA PB 2, and listed and labeled as complying with UL 891; ratings, configurations and features as indicated on the drawings.
- D. Front-Connected Switchboards:
 - 1. Main Device(s): Individually-mounted.
 - 2. Feeder Devices: Panel/group-mounted.
 - 3. Arrangement: Front accessible only (not rear accessible), rear aligned.
 - 4. Gutter Access: Bolted covers.
- E. Service Conditions:
 - 1. Provide switchboards and associated components suitable for operation under the following service conditions without derating:
 - a. Elevation: Less than 6,600 feet.
 - b. Ambient Temperature:
 - 1) Switchboards Containing Molded Case or Insulated Case Circuit Breakers: Between 23 degrees F and 104 degrees F.
- F. Short Circuit Current Rating:
 - 1. Provide switchboards with listed short circuit current rating not less than the available fault current at the installed location as indicated on the drawings.
 - 2. Minimum Rating: 30,000 rms symmetrical amperes.
 - 3. Listed series ratings are acceptable only where specifically indicated.
- G. Selectivity: Where the requirement for selectivity is indicated, furnish products as required to achieve selective coordination.
- H. Main Devices: Configure for bottom incoming feed as indicated or as required for the installation. Provide separate pull section as required to facilitate installation of incoming feed.

- I. Bussing: Sized in accordance with UL 891 temperature rise requirements.
 - 1. Through bus (horizontal cross bus) to be fully rated through full length of switchboard (non-tapered). Tapered bus is not permitted.
 - 2. Provide fully rated neutral bus unless otherwise indicated, with a suitable lug for each feeder or branch circuit requiring a neutral connection.
 - 3. Provide solidly bonded equipment ground bus through full length of switchboard, with a suitable lug for each feeder and branch circuit equipment grounding conductor.
 - 4. Phase and Neutral Bus Material: Copper.
 - 5. Ground Bus Material: Copper.
- J. Conductor Terminations: Suitable for use with the conductors to be installed.
 - 1. Line Conductor Terminations:
 - a. Main and Neutral Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
 - b. Main and Neutral Lug Type: Mechanical.
 - 2. Load Conductor Terminations:
 - a. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
 - b. Lug Type:
 - 1) Provide mechanical lugs unless otherwise indicated.
 - 2) Provide compression lugs where indicated.
- K. Enclosures:
 - 1. Provide NEMA Type 3R enclosure.
 - 2. Finish: Manufacturer's standard unless otherwise indicated.
 - 3. Enclosure Space Heaters:
 - a. Provide in each switchboard section installed outdoors and in unconditioned indoor spaces.
 - b. Size according to manufacturer's recommendations for worst case ambient temperature to prevent condensation.
 - c. Heater Control: Thermostat.
 - d. Heater Power Source: Provide connection to transformer factory-installed in switchboard or suitable external branch circuit as indicated or as required.
 - 4. Outdoor Enclosures:
 - a. Enclosure Type: Non-walk-in type unless otherwise indicated.
 - b. Color: Manufacturer's standard.
 - c. Access Doors: Lockable, with all locks keyed alike.
- L. Future Provisions:
 - 1. Prepare designated spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.
 - 2. Equip distribution sections with full height vertical bussing to accommodate maximum utilization of space for devices.
- M. Internally mounted, factory installed surge protection device to comply with UL 1449, Type 1 and 2
 - 1. Approved by switchboard manufacturer as part of a listed assembly
 - 2. Utilize Metal-Oxide Varistors (MOV) components as primary energy mitigation. Selenium cell, air gaps, gas tubes are not allowed
 - 3. Minimum surge current rating of 120kA per phase / 60kA per mode
 - 4. L-L, L-N, L-G, and N-G protection modes
 - 5. 1000V Voltage protection rating (VPR) for L-N, L-G, and N-G ; 1200V VPR for L-L.
 - 6. Maximum Continuous Operating Voltage not less than 125% of system voltage rating.
- N. Ground Fault Protection: Where ground-fault protection is indicated, provide system listed and labeled as complying with UL 1053.
 - 1. Where overcurrent protective devices equipped with integral ground fault protection are used, provide separate neutral current sensor where applicable.

- O. Arc Flash Energy-Reducing Maintenance Switching: Where indicated, provide a local accessory switch with status indicator light that permits selection of a maintenance mode with alternate electronic trip unit settings for reduced fault clearing time.
- P. Metering: Comply with Section 26 27 13.
- Q. Metering:
 - 1. Provide microprocessor-based digital electrical metering system including all instrument transformers, wiring, and connections necessary for measurements specified.
 - 2. Metering type to be as indicated on Design Drawings.
- R. Instrument Transformers:
 - 1. Comply with IEEE C57.13.
 - 2. Select suitable ratio, burden, and accuracy as required for connected devices.
 - 3. Current Transformers: Connect secondaries to shorting terminal blocks.
 - 4. Potential Transformers: Include primary and secondary fuses with disconnecting means.

2.03 OVERCURRENT PROTECTIVE DEVICES

- A. Circuit Breakers:
 - 1. Interrupting Capacity:
 - a. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than specified minimum requirements.
 - b. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.
 - 2. Molded Case Circuit Breakers:
 - a. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers; listed and labeled as complying with UL 489, and complying with FS W-C-375 where applicable; ratings, configurations, and features as indicated on the drawings.
 - 1) Provide electronic trip circuit breakers for circuit breaker frame sizes 250 amperes and above.
 - b. Minimum Interrupting Capacity:
 - 1) 10,000 rms symmetrical amperes at 240 VAC or 208 VAC.
 - c. Electronic Trip Circuit Breakers: Furnish solid state, microprocessor-based, true rms sensing trip units.
 - 1) Provide the following field-adjustable trip response settings:
 - (a) Long time pickup, adjustable by replacing interchangeable trip unit or by setting dial.
 - (b) Long time delay.
 - (c) Short time pickup and delay.
 - (d) Instantaneous pickup.
 - (e) Ground fault pickup and delay where ground fault protection is indicated.
 - 2) Provide zone selective interlocking capability where indicated, capable of communicating with other electronic trip circuit breakers and external ground fault sensing systems to control short time delay and ground fault delay functions for system coordination purposes.
 - 3) Provide communication capability where indicated: Compatible with system indicated.
 - d. Circuit breakers that are 1200 amp and larger rated, or can be adjusted to be 1200 amp or larger rated: Provide with an energy reducing maintenance switch adjustment to meet the requirements of NEC 240.87.
 - e. Circuit-breaker frame sizes 250 A and larger shall be 100% rated to continuously carry their full ampere capacity.
 - f. Provide the following circuit breaker types where indicated:
 - 1) 100 Percent Rated Circuit Breakers: Listed for application within the switchboard where installed at 100 percent of the continuous current rating.

- 2) Current Limiting Circuit Breakers: Without using fusible elements, designed to limit the let-through energy to a value less than the energy of a one-half cycle wave of the symmetrical prospective current when operating within its current limiting range.
3. Insulated Case Circuit Breakers:
 - a. Description: Quick-make, quick-break, trip-free circuit breakers with two-step stored energy closing mechanism; standard 80 percent rated unless otherwise indicated; listed and labeled as complying with UL 489; ratings, configurations, and features as indicated on the drawings.
 - b. Operation:
 - 1) Provide manually operated circuit breakers unless otherwise indicated.
 - 2) Provide electrically operated circuit breakers where indicated.
 - 3) Pad-Lock Provision: For preventing circuit breaker closing operation.
 - c. Construction:
 - 1) Provide fixed-mount circuit breakers unless otherwise indicated.
 - d. Minimum Interrupting Capacity:
 - 1) 42,000 rms symmetrical amperes at 240 VAC or 208 VAC.
 - e. Trip Units: Solid state, microprocessor-based, true rms sensing.
 - 1) Provide the following field-adjustable trip response settings:
 - (a) Long time pickup, adjustable by setting dial.
 - (b) Long time delay.
 - (c) Short time pickup and delay.
 - (d) Instantaneous pickup.
 - (e) Ground fault pickup and delay where ground fault protection is indicated.
 - 2) Provide zone selective interlocking capability where indicated, capable of communicating with other electronic trip circuit breakers and external ground fault sensing systems to control short time delay and ground fault delay functions for system coordination purposes.
 - 3) Provide communication capability where indicated: Compatible with system indicated.
 - f. Circuit breakers that are 1200 amp and larger rated, or can be adjusted to be 1200 amp or larger rated: Provide with an energy reducing maintenance switch adjustment to meet the requirements of NEC 240.87.
 - g. Provide the following circuit breaker types where indicated:
 - 1) 100 Percent Rated Circuit Breakers: Listed for application within the switchboard where installed at 100 percent of the continuous current rating.
 - 2) Current Limiting Circuit Breakers: Without using fusible elements, designed to limit the let-through energy to a value less than the energy of a one-half cycle wave of the symmetrical prospective current when operating within its current limiting range.

2.04 SOURCE QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Factory test switchboards according to NEMA PB 2, including the following production (routine) tests on each switchboard assembly or component:
 1. Dielectric tests.
 2. Mechanical operation tests.
 3. Grounding of instrument transformer cases test.
 4. Electrical operation and control wiring tests, including polarity and sequence tests.
 5. Ground-fault sensing equipment test.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify field measurements are as indicated.

- B. Verify ratings and configurations of the switchboards and associated components are consistent with the indicated requirements.
- C. Verify mounting surfaces are ready to receive switchboards.
- D. Verify conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install switchboards in accordance with NECA 1 (general workmanship), NECA 400, and NEMA PB 2.1.
- C. Arrange equipment to provide required clearances and maintenance access, including accommodations for any drawout devices.
- D. Provide required support and attachment in accordance with Section 26 05 00.
- E. Install switchboards plumb and level.
- F. Unless otherwise indicated, mount switchboards on properly sized 3" high concrete pad constructed in accordance with Section 03 30 00. Pad should extend nominally 2-inches beyond edges of the equipment.
- G. Freestanding, rear-aligned, front-accessible, group-mounted circuit breaker type, fully enclosed with bussing and hardware provisions for the addition of future circuit breakers. Assemblies rated 800A or below may be wall-mounted.
- H. Provide grounding and bonding in accordance with Section 26 05 00.
- I. Install field-installed devices, components, and accessories.
- J. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.
- K. Set field-adjustable circuit breaker tripping function settings as determined by overcurrent protective device coordination study performed in accordance with Section 26 05 73.
- L. Set field-adjustable ground fault protection pickup and time delay settings as indicated.
- M. Provide filler plates to cover unused spaces in switchboards.
- N. Identify switchboards in accordance with Section 26 05 00.

3.03 FIELD QUALITY CONTROL

- A. Provide services of a manufacturer's authorized representative to observe installation and assist in inspection and testing. Include manufacturer's reports with submittals.
- B. Before energizing switchboard, perform insulation resistance testing in accordance with NECA 400 and NEMA PB 2.1.
- C. Inspect and test in accordance with NETA ATS, except Section 4.
- D. Perform inspections and tests listed in NETA ATS, Section 7.1.
- E. Molded Case and Insulated Case Circuit Breakers: Perform inspections and tests listed in NETA ATS, Section 7.6.1.1 for all main circuit breakers and circuit breakers larger than 400 amperes. Tests listed as optional are not required, except for the following:
 - 1. Perform insulation-resistance tests on all control wiring with respect to ground.
 - 2. Test functions of the trip unit by means of secondary injection.
- F. Ground Fault Protection Systems: Test in accordance with manufacturer's instructions as required by NFPA 70.
 - 1. Perform inspections and tests listed in NETA ATS, Section 7.14. The insulation-resistance test on control wiring listed as optional is not required.
- G. Meters: Perform inspections and tests listed in NETA ATS, Section 7.11.2.

- H. Instrument Transformers: Perform inspections and tests listed in NETA ATS, Section 7.10. The dielectric withstand tests on primary windings with secondary windings connected to ground listed as optional are not required.
- I. Correct deficiencies and replace damaged or defective switchboards or associated components.
- J. Submit detailed reports indicating inspection and testing results and corrective actions taken.

3.04 ADJUSTING

- A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.
- B. Adjust alignment of switchboard covers and doors.

3.05 CLEANING

- A. Clean dirt and debris from switchboard enclosures and components according to manufacturer's instructions.
- B. Repair scratched or marred surfaces to match original factory finish.

3.06 CLOSEOUT ACTIVITIES

- A. Training: Train Owner's personnel on operation, adjustment, and maintenance of switchboard and associated devices.
 - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
 - 2. Provide minimum of two hours of training.
 - 3. Instructor: Manufacturer's authorized representative.
 - 4. Location: At project site.

3.07 PROTECTION

- A. Protect installed switchboards from subsequent construction operations.

END OF SECTION 26 24 13

**SECTION 26 24 16
PANELBOARDS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Power distribution panelboards.
- B. Overcurrent protective devices for panelboards.

1.02 REFERENCE STANDARDS

- A. FS W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service.
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction.
- C. NECA 407 - Standard for Installing and Maintaining Panelboards.
- D. NEMA PB 1 - Panelboards.
- E. NEMA PB 1.1 - General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
- F. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems.
- G. NFPA 70 - National Electrical Code.
- H. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations.
- I. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations.
- J. UL 67 - Panelboards.
- K. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate arrangement of electrical equipment with dimensions and clearance requirements of actual equipment to be installed.
 - 2. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
 - 3. Notify Owner of conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.04 SUBMITTALS

- A. See Section 26 05 00 - Common Work Results for Electrical, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for panelboards, enclosures, overcurrent protective devices, and other installed components and accessories.
- C. Shop Drawings: Indicate outline and support point dimensions, voltage, main bus ampacity, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- E. Project Record Documents: Record actual installed locations of panelboards and actual installed circuiting arrangements.
- F. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.
- G. Furnish two of each different enclosure keys to the Owner.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store panelboards in accordance with manufacturer's instructions and NECA 407.
- B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- C. Handle carefully in accordance with manufacturer's written instructions to avoid damage to panelboard internal components, enclosure, and finish.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. ABB.
- B. Eaton Corporation
- C. Schneider Electric; Square D Products
- D. Siemens Industry, Inc

2.02 PANELBOARDS - GENERAL REQUIREMENTS

- A. Provide products listed, classified, and labeled as suitable for the purpose intended.
- B. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
 - 1. Elevation: Less than 6,600 feet.
 - 2. Ambient Temperature:
 - a. Panelboards Containing Circuit Breakers: Between 23 degrees F and 104 degrees F.
- C. Short Circuit Current Rating:
 - 1. Provide panelboards with listed short circuit current rating not less than the available fault current at the installed location as indicated on the drawings.
- D. Mains: Configure for top or bottom incoming feed as indicated or as required for installation.
- E. Branch Overcurrent Protective Devices: Replaceable without disturbing adjacent devices.
- F. Bussing: Sized in accordance with UL 67 temperature rise requirements.
 - 1. Provide fully rated neutral bus unless otherwise indicated, with a suitable lug for each feeder or branch circuit requiring a neutral connection.
 - 2. Provide solidly bonded equipment ground bus in each panelboard, with a suitable lug for each feeder and branch circuit equipment grounding conductor.
- G. Conductor Terminations: Suitable for use with the conductors to be installed.
- H. Provide NEMA Type 3R enclosure.s: Comply with NEMA EN 10250, and list and label as complying with UL 50 and UL 50E.
 - 1. Boxes: Galvanized steel unless otherwise indicated.
 - a. Provide painted steel boxes for surface-mounted panelboards where indicated, finish to match fronts.
 - 2. Fronts:
 - a. Fronts for Surface-Mounted Enclosures: Same dimensions as boxes.
 - b. Finish for Painted Steel Fronts: Manufacturer's standard grey unless otherwise indicated.
 - 3. Lockable Doors: Locks keyed alike unless otherwise indicated.
- I. Future Provisions: Prepare all unused spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.
- J. Load centers are not acceptable.

2.03 POWER DISTRIBUTION PANELBOARDS

- A. Description: Panelboards complying with NEMA PB 1, power and feeder distribution type, circuit breaker type, and listed and labeled as complying with UL 67; ratings, configurations and features as indicated on the drawings.
- B. Conductor Terminations:
 - 1. Main and Neutral Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
 - 2. Main and Neutral Lug Type: Mechanical.
- C. Bussing:
 - 1. Phase and Neutral Bus Material: Aluminum.
 - 2. Ground Bus Material: Aluminum.
- D. Circuit Breakers:
 - 1. Provide bolt-on type or plug-in type secured with locking mechanical restraints.
 - 2. Provide thermal magnetic circuit breakers unless otherwise indicated.
- E. Enclosures:
 - 1. Provide surface-mounted enclosures unless otherwise indicated.
 - 2. Fronts: Provide trims to cover access to load terminals, wiring gutters, and other live parts, with exposed access to overcurrent protective device handles.
 - 3. Provide clear plastic circuit directory holder mounted on inside of door.

2.04 OVERCURRENT PROTECTIVE DEVICES

- A. Molded Case Circuit Breakers:
 - 1. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers listed and labeled as complying with UL 489, and complying with FS W-C-375 where applicable; ratings, configurations, and features as indicated on the drawings.
 - 2. Provide circuit breakers with an interrupting capacity of 10,000 rms symmetrical amps.
 - 3. Conductor Terminations:
 - a. Provide mechanical lugs unless otherwise indicated.
 - b. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
 - 4. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
 - a. Provide field-adjustable magnetic instantaneous trip setting for circuit breaker frame sizes 225 amperes and larger.
 - 5. Multi-Pole Circuit Breakers: Furnish with common trip for all poles.
 - 6. Provide the following circuit breaker types where indicated:
 - a. Current Limiting Circuit Breakers: Without using fusible elements, designed to limit the let-through energy to a value less than the energy of a one-half cycle wave of the symmetrical prospective current when operating within its current limiting range.
 - 7. Provide multi-pole circuit breakers for multi-wire branch circuits as required by NFPA 70.

2.05 SOURCE QUALITY CONTROL

- A. Factory test panelboards according to NEMA PB 1.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify field measurements are as indicated.
- B. Verify the ratings and configurations of the panelboards and associated components are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive panelboards.
- D. Verify conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Install panelboards in accordance with NECA 407 and NEMA PB 1.1.
- D. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- E. Provide required support and attachment in accordance with Section 26 05 00.
- F. Install panelboards plumb.
- G. Mount panelboards such that the highest position of any operating handle for circuit breakers or switches does not exceed 79 inches above the floor or working platform.
- H. Provide grounding and bonding in accordance with Section 26 05 00.
- I. Install field-installed branch devices, components, and accessories.
- J. Multi-Wire Branch Circuits: Group grounded and ungrounded conductors together in the panelboard as required by NFPA 70.
- K. Set field-adjustable circuit breaker tripping function settings as indicated.
- L. Identify panelboards in accordance with Section 26 05 00.

3.03 FIELD QUALITY CONTROL

- A. Inspect and test in accordance with NETA ATS, except Section 4.
- B. Molded Case Circuit Breakers: Perform inspections and tests listed in NETA ATS, Section 7.6.1.1 for all main circuit breakers. Tests listed as optional are not required, except for the following:
 - 1. Perform insulation-resistance tests on control wiring with respect to ground.
 - 2. Test functions of the trip unit by means of secondary injection.
- C. Procure services of a qualified manufacturer's representative to observe installation and assist in inspection, testing, and adjusting. Include manufacturer's reports with field quality control submittals.
- D. Correct deficiencies and replace damaged or defective panelboards or associated components.

3.04 ADJUSTING

- A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.
- B. Adjust alignment of panelboard fronts.
- C. Load Balancing: For each panelboard, rearrange circuits such that the difference between each measured steady state phase load does not exceed 20 percent and adjust circuit directories accordingly. Maintain proper phasing for multi-wire branch circuits.

3.05 CLEANING

- A. Clean dirt and debris from panelboard enclosures and components according to manufacturer's instructions.
- B. Repair scratched or marred exterior surfaces to match original factory finish.

END OF SECTION 26 24 16

**SECTION 26 27 13
ELECTRICITY METERING**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Equipment for Owner Electricity Metering.
- B. Basic Electricity Metering:
 - 1. Multi-circuit electricity meters.

1.02 REFERENCE STANDARDS

- A. IEEE C57.13 - IEEE Standard Requirements for Instrument Transformers.
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction.
- C. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems.
- D. NFPA 70 - National Electrical Code.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate work to provide equipment suitable for interface with electricity metering systems to be provided.
 - 2. Coordinate the work with other installers to provide communication lines required for electricity metering system interface.
 - 3. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.04 SUBMITTALS

- A. See Section 26 05 00 - Common Work Results for Electrical, for submittal procedures.
- B. Product Data:
 - 1. Provide manufacturer's standard catalog pages and data sheets for electricity metering systems and associated components and accessories.
 - 2. Include ratings, configurations, standard wiring diagrams, dimensions, service condition requirements, and installed features.
 - 3. Include manufacturer's published data tables with complete listing of metering device Modbus registers and/or BacNet Object IDs with associated data descriptions, formats, units, scale factors.
- C. Shop Drawings:
 - 1. Include system interconnection schematic diagrams showing all factory and field connections. Diagrams to include potential transformer (PT) and current transformer (CT) connections that clearly indicate the point(s) of metering device sensing within the electrical distribution system to be metered and indicate the CT orientation (polarity) with respect to the metered circuit.
 - 2. Include requirements for interface with other systems.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- E. Field Quality Control Test Reports.
 - 1. Meter data capture in comma separated value (CSV) or extensible markup language (XML) format showing successful meter data capture of all installed metering devices and associated metering points
 - 2. Meter data must include (120) consecutive hours of electrical system operation on active electrical feeders.
 - 3. Meter data must be signed (positive or negative) to indicate directionality of power flow.

4. Meter data must have decipherable column headers to indicate associated units and scale factors.
- F. Project Record Documents:
 1. Final as built system interconnection schematic diagrams.
 2. Final equipment settings:
 - a. Device usernames and passwords updated from factory defaults.
 - b. TCP/IPv4 network settings for all Ethernet enabled meters configured for Modbus/TCP or BacNet/TCP
 - c. TCP/IPv4 network settings for all Ethernet enabled electrical metering equipment gateways and/or protocol converters.
 - d. Modbus device IDs for all RS485 enabled meters.
 - e. Meter device configuration reports.
 - f. Meter device setting file exports.
- G. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.

1.05 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Electricity Meters:
 1. Source Limitations: Provide electricity meters produced by single manufacturer and obtained from single supplier.

2.02 EQUIPMENT FOR OWNER ELECTRICITY METERING

- A. Provide microprocessor-based digital electricity metering systems including instrument transformers, wiring, and connections necessary for measurements specified.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Provide electricity metering systems and associated components compatible with the equipment and associated circuits to be metered.
- D. Service Conditions: Provide electricity meters suitable for operation under the service conditions at the installed location.
- E. Meters
 1. Designed for multifunction electrical measurement on 3 phase power systems. Meter to perform to spec in harsh electrical applications in high and low voltage power systems.
 2. Support 3 element Wye, 2.5 element Wye, 2 element Delta, 4 wire Delta systems.
 3. Surge Withstand: conform to IEEE C37.90.1
 4. Fault Current Withstand: 100 Amps for 10 seconds, 300 Amps for 3 seconds, and 500 Amps for 1 second.
 5. Inputs and outputs: galvanically isolated to 2500 VAC.
 6. Bi-directional metering functionality is required for all meter products under this Section.
 - a. Positive power and energy to be representative of power flow entering the associated metering CT via the polarity marked side.
 - b. Negative power and energy to be representative of power flow entering the associated metering CT via the non-polarity marked side.
 - c. Negative power flow data available in the same register as positive power flow data.
 - d. Separate logging of positive and negative energy accumulation.
 - e. Net energy combined logging of positive and negative energy accumulation
 - 1) Positive energy results in additive accumulation.

2) Negative energy results in subtractive accumulation

- F. Enclosures:
 - 1. To be furnished by the metering equipment manufacturer as a complete and listed system.
 - 2. Provide NEMA Type 3R or 4 enclosures.
- G. Instrument Transformers:
 - 1. Comply with IEEE C57.13, where applicable.
 - 2. Select suitable ratio, burden, and accuracy as required for connected devices, including protective relay equipment that may be present in the design.
 - 3. Select suitable insulation/voltage class for the circuit to be metered.
 - 4. Current Transformers:
 - a. Solid Core CTs for less than or equal to 400A primary metering applications unless otherwise noted in Design.
 - b. Split Core CTs for 600A and greater primary metering applications unless otherwise noted in Design.
 - c. Rogowski CTs permitted only with pre-bid approval or as indicated in the Design.
 - d. Compatible with connected meters; replace meters damaged by connection of incompatible current transformers.
 - e. Provide shorting terminal blocks for connection of secondaries where applicable.
 - f. CT line voltage terminals to be finger safe.
 - 5. Potential Transformers:
 - a. Include primary and secondary fuses with disconnecting means.
 - b. CT line voltage terminals to be finger safe.

2.03 BASIC ELECTRICITY METERS

- A. Electricity meters with "M|B" annotations as indicated on Design Documents are subject to the requirements of this Part. Basic electricity meters can be Single Circuit, Multi-Circuit or Branch Circuit type electricity meters as indicated on Design Documents.
- B. Basic Electricity Meter equipment to be connected to Facility Building Management System (BMS)
 - 1. Basic meters to communicate with Facility BMS via BACnet-IP communication protocol.
 - 2. See Design Documentation for additional requirements.
- C. Basic Electricity Meter equipment to be provided with Data Acquisition Servers (DAS)
 - 1. Basic meters to communicate with DAS via BACnet-IP communication protocol.
 - 2. DAS equipment, if provided, to be dedicated to Division 26 electricity meter data acquisition, storage, display and retrieval.
 - 3. DAS to be capable of logging hourly interval data from meters and retaining logged data in non-volatile memory for a minimum of 36 months.
 - 4. See Design Documentation for additional requirements
- D. Basic Electricity Meter equipment to be connected to Microgrid Energy Management System (MEMS).
 - 1. Basic meters to communicate with MEMS via Modbus-TCP communication protocol.
 - 2. MEMS to be capable of logging (15) fifteen minute interval data from meters.
 - 3. See Section 263713 - Microgrid Energy Management System for additional requirements.
- E. Multi-Circuit Electricity Meter
 - 1. Basis of Design:
 - a. eGauge EG4030W
 - 2. Number of metering points:
 - a. Capable of metering 10 or more three phase circuits via a single multi-point meter assembly and associated enclosure.
 - b. Capable of metering 30 or more single phase circuits via a single multi-point meter assembly and associated enclosure.

3. Display:
 - a. Optional integral or remote color LED touch screen display to display real time data for each metered point.
 - b. See Design Documents for inclusion and desired location.
 4. Enclosure:
 - a. Integrate into switchgear or switchboard assembly or into dedicated cabinet. If switchgear/switchboard integrated, the metering section or cubicle will include dielectric barriers to separate the meter equipment space from live electrical components, shock hazards and Arc Flash hazards.
 - b. Include terminal blocks, fuses, power supplies and other accessories as required to satisfy the Design.
- F. Basic Electricity Metering Product Requirements:
1. Accuracy:
 - a. Real Power/Energy: Plus/minus 0.5 percent, complying with ANSI C12.20 accuracy and IEC 62053-21, Class 0.5, or IEC 60253-22, Class 0.5S.
 - b. Reactive Power/Energy: Plus/minus 1.0 percent, complying with IEC 62053-24, Class 1, or better.
 - c. Line to Neutral Voltage: Plus/minus 0.2 percent.
 - d. Line to Line Voltage: Plus/minus 0.4 percent.
 - e. Current: Plus/minus 0.2 percent.
 - f. Power Factor: Plus/minus 1.0 percent.
 - g. Frequency: Plus/minus 0.01 Hz.
 2. Sampling Frequency, Update Rate and Harmonics:
 - a. Sampling frequency: 400 per cycle (24,000Hz)
 - b. Update rate: 2 seconds (maximum)
 - c. Harmonics Resolution: N/A.
 3. Measured Parameters:
 - a. Real energy (kWh); per phase and total of phases.
 - b. Reactive energy (kVARh); per phase and total of phases.
 - c. Apparent energy (kVAh); per phase and total of phases.
 - d. Real power (kW); Average and maximum over a user-specified interval of one hour or less.
 - e. Reactive power (kVAR); Average and maximum over a user-specified interval of one hour or less.
 - f. Apparent power (kVA); Average and maximum over a user-specified interval of one hour or less.
 - g. Bi-directional Energy Measurements:
 - 1) Real/active energy (kWh) and apparent energy (kVAh); imported (from the grid), exported (to the grid), and signed net total.
 - 2) Reactive energy (kVARh); imported (from the grid) and exported (to the grid), per quadrant as defined by IEEE 1459.
 - 3) Maximum demand; real/active power (kW), reactive power (kVAR), and apparent power (kVA); imported (from the grid) and exported (to the grid).
 - h. Current; per phase and average of phases.
 - i. Voltage; line-to-line and line-to-neutral; per phase and average of phases.
 - j. Power factor; per phase and average of phases.
 - k. Frequency.
 4. Communications:
 - a. Compatible with connected systems. Provide accessories necessary for proper interface.
 - b. Protocol converters not permitted unless otherwise noted in Design Documentation or this Section.
 - c. Serial Communications (at least one of the following):

- 1) RS-485, 2-wire: support for Modbus RTU
- 2) RS-485, 2-wire; support for BACnet MS/TP
- d. Ethernet Communications (at least one of the following):
 - 1) Modbus TCP/IP
 - 2) BacNet IP

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify field measurements are as indicated.
- B. Verify the ratings and configurations of metering systems and associated components are consistent with the indicated requirements.
- C. Verify mounting surfaces are ready to receive meters.
- D. Verify conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Provide required support and attachment components in accordance with Section 26 05 29.
- D. Provide grounding and bonding in accordance with Section 26 05 00.
- E. Provide fuses complying with Section 26 28 13 as required.
- F. Identify meters and associated wiring in accordance with Section 26 05 00.

3.03 FIELD QUALITY CONTROL

- A. Inspect and test in accordance with NETA ATS, except Section 4.
- B. Meters: Perform inspections and tests listed in NETA ATS, Section 7.11.2.
- C. Instrument Transformers: Perform inspections and tests listed in NETA ATS, Section 7.10. The dielectric withstand tests on primary windings with secondary windings connected to ground listed as optional are not required.
- D. Correct deficiencies and replace damaged or defective metering system components.
- E. Submit detailed reports indicating inspection and testing results and corrective actions taken.
 1. Testing results report to include meter CT polarity and CT/PT phase relationship verification with respect to the metered circuit and associated directionality of current and power flows.
 2. See Submittals 1.04.E for additional field quality control test reporting requirements.

3.04 ADJUSTING

- A. Program system parameters according to requirements of Owner.

3.05 CLEANING

- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.06 CLOSEOUT ACTIVITIES

- A. Training: Train Owner's personnel on operation, adjustment, and maintenance of system.
 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
 2. Provide minimum of two hours of training.
 3. Instructor: Manufacturer's authorized representative.
 4. Location: Remote via online meeting or webinar..

3.07 PROTECTION

- A. Protect installed system components from subsequent construction operations.

END OF SECTION 26 27 13

**SECTION 26 28 13
FUSES**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Fuses.

1.02 REFERENCE STANDARDS

- A. NEMA FU 1 - Low Voltage Cartridge Fuses.
- B. NFPA 70 - National Electrical Code.
- C. UL 248-1 - Low-Voltage Fuses - Part 1: General Requirements.
- D. UL 248-4 - Low-Voltage Fuses - Part 4: Class CC Fuses.
- E. UL 248-12 - Low-Voltage Fuses - Part 12: Class R Fuses.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate fuse clips furnished in equipment provided under other sections for compatibility with indicated fuses.
 - a. Fusible Enclosed Switches: See Section 26 28 16.16.
 - 2. Coordinate fuse requirements according to manufacturer's recommendations and nameplate data for actual equipment to be installed.

1.04 SUBMITTALS

- A. See Section 26 05 00 - Common Work Results for Electrical, for submittal procedures.
- B. Product Data: Provide manufacturer's standard data sheets including voltage and current ratings, interrupting ratings, time-current curves, and current limitation curves.
- C. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Extra Fuses: One set(s) of three for each type and size installed.
 - 2. Fuse Pullers: One set(s) compatible with each type and size installed.

1.05 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Bussmann, a division of Eaton Corporation.
- B. Littelfuse, Inc.
- C. Mersen.

2.02 APPLICATIONS

- A. Service Entrance:
 - 1. Fusible Switches up to 600 Amperes: Class RK1, time-delay.
- B. Feeders:
 - 1. Fusible Switches up to 600 Amperes: Class RK1, time-delay.
- C. Primary Protection for Control Transformers: Class CC, time-delay.

2.03 FUSES

- A. Provide products listed, classified, and labeled as suitable for the purpose intended.
- B. Unless specifically indicated to be excluded, provide fuses for all fusible equipment as required for a complete operating system.
- C. Provide fuses of the same type, rating, and manufacturer within the same switch.
- D. Comply with UL 248-1.
- E. Unless otherwise indicated, provide cartridge type fuses complying with NEMA FU 1, Class and ratings as indicated.
- F. Voltage Rating: Suitable for circuit voltage.
- G. Class R Fuses: Comply with UL 248-12.
- H. Class CC Fuses: Comply with UL 248-4.
- I. Selectivity: Where the requirement for selectivity is indicated, furnish products as required to achieve selective coordination.
- J. Provide the following accessories where indicated or where required to complete installation:
 - 1. Fuseholders: Compatible with indicated fuses.
 - 2. Fuse Reducers: For adapting indicated fuses to permit installation in switch designed for fuses with larger ampere ratings.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify fuse ratings are consistent with circuit voltage and manufacturer's recommendations and nameplate data for equipment.
- B. Verify conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Do not install fuses until circuits are ready to be energized.
- B. Install fuses with label oriented such that manufacturer, type, and size are easily read.

END OF SECTION 26 28 13

**SECTION 26 28 16.16
ENCLOSED SWITCHES**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Enclosed safety switches.

1.02 REFERENCE STANDARDS

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction.
- B. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
- C. NEMA BS 31047 - Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum).
- D. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems.
- E. NFPA 70 - National Electrical Code.
- F. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations.
- G. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations.
- H. UL 98 - Enclosed and Dead-Front Switches.
- I. UL 869A - Reference Standard for Service Equipment.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the work with other trades. Avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and within working clearances for electrical equipment required by NFPA 70.
 - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 3. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
 - 4. Notify Owner of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.04 SUBMITTALS

- A. See Section 26 05 00 - Common Work Results for Electrical, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for enclosed switches and other installed components and accessories.
- C. Shop Drawings: Indicate outline and support point dimensions, voltage and current ratings, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
 - 1. Include dimensioned plan and elevation views of enclosed switches and adjacent equipment with all required clearances indicated.
 - 2. Include wiring diagrams showing all factory and field connections.
- D. Field Quality Control Test Reports.
- E. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- F. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.
- G. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 26 28 13 for requirements for spare fuses.

1.05 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- B. Handle carefully in accordance with manufacturer's written instructions to avoid damage to enclosed switch internal components, enclosure, and finish.

1.07 FIELD CONDITIONS

- A. Maintain ambient temperature between -22 degrees F and 104 degrees F during and after installation of enclosed switches.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. ABB.
- B. Eaton Corporation.
- C. Schneider Electric; Square D Products.
- D. Siemens Industry, Inc.

2.02 ENCLOSED SAFETY SWITCHES

- A. Description: Quick-make, quick-break enclosed safety switches listed and labeled as complying with UL 98; heavy duty.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
 - 1. Elevation: Less than 6,600 feet.
 - 2. Ambient Temperature: Between -22 degrees F and 104 degrees F.
- D. Horsepower Rating: Suitable for connected load.
- E. Voltage Rating: Suitable for circuit voltage.
- F. Short Circuit Current Rating:
 - 1. Provide enclosed safety switches, when protected by the fuses or supply side overcurrent protective devices to be installed, with listed short circuit current rating not less than the available fault current at the installed location as indicated on the drawings.
 - 2. Minimum Ratings:
 - a. Heavy Duty Single Throw Switches Protected by Class R, Class J, Class L, or Class T Fuses: 200,000 rms symmetrical amperes.
- G. Enclosed Safety Switches Used for Service Entrance: Listed and labeled as suitable for use as service equipment according to UL 869A.
- H. Provide with switch blade contact position that is visible when the cover is open.
- I. Fuse Clips for Fusible Switches: As required to accept fuses indicated.
 - 1. Where NEMA Class R fuses are installed, provide rejection feature to prevent installation of fuses other than Class R.

- J. Conductor Terminations: Suitable for use with the conductors to be installed.
- K. Provide insulated, groundable fully rated solid neutral assembly where a neutral connection is required, with a suitable lug for terminating each neutral conductor.
- L. Provide solidly bonded equipment ground bus in each enclosed safety switch, with a suitable lug for terminating each equipment grounding conductor.
- M. Enclosures: Comply with NEMA EN 10250, and list and label as complying with UL 50 and UL 50E.
 - 1. Environment Type per NEMA EN 10250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Indoor Clean, Dry Locations: Type 1.
 - b. Outdoor Locations: Type 3R.
 - 2. Finish for Painted Steel Enclosures: Manufacturer's standard, factory applied grey unless otherwise indicated.
- N. Provide safety interlock to prevent opening the cover with the switch in the ON position with capability of overriding interlock for testing purposes.
- O. Heavy Duty Switches:
 - 1. Comply with NEMA BS 31047.
 - 2. Conductor Terminations:
 - a. Provide mechanical lugs unless otherwise indicated.
 - b. Provide compression lugs where indicated.
 - c. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
 - 3. Provide externally operable handle with means for locking in the OFF position, capable of accepting three padlocks.
 - a. Provide means for locking handle in the ON position where indicated.
- P. Provide the following features and accessories where indicated or where required to complete installation:
 - 1. Hubs: As required for environment type; sized to accept conduits to be installed.
 - 2. Integral fuse pullers.
 - 3. Auxiliary Switch: SPDT switch suitable for connection to system indicated, with auxiliary contact operation before switch blades open and after switch blades close.
 - 4. Viewing Window: Positioned over switch blades for visual confirmation of contact position with door closed.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify field measurements are as indicated.
- B. Verify ratings of the enclosed switches are consistent with the indicated requirements.
- C. Verify mounting surfaces are ready to receive enclosed safety switches.
- D. Verify conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Provide required support and attachment in accordance with Section 26 05 00.
- E. Install enclosed switches plumb.

- F. Except where indicated to be mounted adjacent to the equipment they supply, mount enclosed switches such that the highest position of the operating handle does not exceed 79 inches above the floor or working platform.
- G. Provide grounding and bonding in accordance with Section 26 05 00.
- H. Provide fuses complying with Section 26 28 13 for fusible switches as indicated or as required by equipment manufacturer's recommendations.
- I. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.
- J. Identify enclosed switches in accordance with Section 26 05 00.

3.03 FIELD QUALITY CONTROL

- A. Inspect and test in accordance with NETA ATS, except Section 4.
- B. Perform inspections and tests listed in NETA ATS, Section 7.5.1.1.
- C. Correct deficiencies and replace damaged or defective enclosed safety switches or associated components.

3.04 ADJUSTING

- A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

3.05 CLEANING

- A. Clean dirt and debris from switch enclosures and components according to manufacturer's instructions.
- B. Repair scratched or marred exterior surfaces to match original factory finish.

END OF SECTION 26 28 16.16

**SECTION 26 31 00
PHOTOVOLTAIC COLLECTORS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Photovoltaic System Requirements
- B. Photovoltaic Modules
- C. Photovoltaic Inverters
- D. Photovoltaic Module Power Optimizer
- E. Photovoltaic Module Mounting System
- F. Balance of System Components
- G. Monitoring System
- H. Photovoltaic System Communications for Supervisory Control by Microgrid Energy Management System

1.02 SYSTEM DESCRIPTION

- A. Provide Delegated Design PV electrical system complete with installation design drawings, facility structural adequacy and racking system structural adequacy calculations, annual energy production estimates, array layout and shading diagrams, meeting the design criteria performed by or under the supervision of a Professional Engineer licensed in the State in which the Project is located. The Delegated Design PV Contractor is responsible for providing signed/stamped/dated construction and permit drawings.
- B. Complete PV system consists of PV modules, mounting system, AC and DC disconnects, power inverters, conductors, conduit, wire management, monitoring devices, over current protection, and other accessories needed for proper operation and code compliance. PV system may also consist of disconnecting combiner boxes and wiring gutters. Integrate complete system into the facility electrical system without impact to the utility service or power quality.
- C. Minimum power (AC nameplate) output rating at the service voltage indicated on the Drawings.
- D. Guarantee electrical work for a period of two years following date of substantial completion.
- E. Capable of supervisory control by a microgrid energy management system using Ethernet network routable protocols to operate PV system inverters via Common Smart Inverter Profile (CSIP) to ensure microgrid island operation stability.

1.03 REFERENCE STANDARDS

- A. ASCE 7 - Minimum Design Loads and Associated Criteria for Buildings and Other Structures.
- B. IEC 61215-1 - Terrestrial Photovoltaic (PV) Modules - Design Qualification and Type Approval - Part 1: Test Requirements.
- C. IEC 61215-1-1 - Terrestrial Photovoltaic (PV) Modules - Design Qualification and Type Approval - Part 1-1: Special Requirements for Testing of Crystalline Silicon Photovoltaic (PV) Modules.
- D. IEC 61215-2 - Terrestrial Photovoltaic (PV) Modules - Design Qualification and Type Approval - Part 2: Test Procedures.
- E. NECA 1 - Standard for Good Workmanship in Electrical Construction.
- F. NECA 412 - Standard for Installing and Maintaining Photovoltaic (PV) Power Systems.
- G. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
- H. NFPA 70 - National Electrical Code.

- I. UL 489B - Outline of Investigation for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures for Use with Photovoltaic (PV) Systems.
- J. UL 869A - Reference Standard for Service Equipment.
- K. UL 1699B - Outline of Investigation for Photovoltaic (PV) DC Arc-Fault Circuit Protection; Current Edition.
- L. UL 1703 - Flat Plate Photovoltaic Modules and Panels.
- M. UL 1741 - Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources.
- N. UL 1741-SB - Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources.
- O. UL 2579 - Low-Voltage Fuses - Fuses for Photovoltaic Systems.
- P. UL 2703 - Standard Mounting Systems, Mounting Devices, Clamping/Retention Devices, and Grounding Lugs for Use with Flat-Plate Photovoltaic Modules and Panels.
- Q. UL 3741 - Photovoltaic Hazard Control.
- R. UL 61730-1 - Photovoltaic (PV) Module Safety Qualification – Part 1: Requirements for Construction.
- S. UL 61730-2 - Photovoltaic (PV) Module Safety Qualification – Part 2: Requirements for Testing.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the spaces dedicated for photovoltaic system components.
 - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 3. Notify Owner of conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
 - 4. Coordinate installation and testing of system communications cabling and equipment with Microgrid Energy Management System vendor.
 - 5. Coordinate system installation with Battery Energy Storage System (BESS) and Microgrid Energy Management System .
 - 6. Provide disconnecting means to isolate photovoltaic system from facility electrical distribution system and vice versa.
- B. Preinstallation Meeting: Convene one week prior to commencing work of this section; require attendance of affected installers. Include adequate instruction on the electrical hazards associated with photovoltaic systems and appropriate safety procedures to be followed.
- C. Rebates and Incentives: Prepare and submit documentation as required for Owner to secure funds from available federal, state, and utility company rebate and incentive programs. Notify Owner of time constraints affecting program qualification.
 - 1. Include copies of documentation with submittals.
- D. Utility Interconnection:
 - 1. Prepare and submit documentation as required for securing utility interconnection agreement between Owner and Utility Company.
 - a. Include copies of documentation with submittals.
 - 2. Preinstallation Meeting: Convene one week prior to commencing work of this section to review interconnection requirements and details with Utility Company representative.
 - 3. Coordinate with Utility Company to provide utility metering and PV system disconnecting means to comply with Utility requirements and suitable for PV system operation.
 - 4. Arrange for inspections and secure permits necessary to obtain Utility Company approval of system.

1.05 SUBMITTALS

- A. See Section 26 05 00 - Common Work Results for Electrical, for submittal procedures.
- B. Design Documents: Prepare and submit information required for plan review and permitting by authorities having jurisdiction, including but not limited to floor plans, riser diagrams, details, and description of operation, including rapid shutdown functionality.
- C. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product. Include ratings, configurations, standard wiring diagrams, outline and support point dimensions, finishes, weights, service condition requirements, and installed features.
 - 1. To facilitate microgrid energy management system controls integration, provide PV inverter product data sheets with complete listing of status and control registers available via at least one of the following protocols:
 - a. Modbus/TCP
 - b. IEEE 2030.5
- D. Shop Drawings: Include the following as a minimum:
 - 1. Dimensioned plan views and sections indicating locations of system components, required clearances, attachment locations and details, and proposed size, type, and routing of conduits and cables.
 - 2. System interconnection schematic diagrams showing factory and field connections.
 - 3. Include proposed locations of roof penetrations and proposed methods for sealing.
 - 4. Raceway conductor sizing.
 - 5. Grounding and bonding details.
- E. Design Data: Include the following as a minimum:
 - 1. Structural calculations for equipment and mounting system, certified by structural engineer licensed in the state in which the project is located.
 - 2. Electrical calculations for array and associated equipment other than the basis of design products and configuration.
 - 3. DC Source and output circuit voltage drop calculations.
 - 4. PV System annual energy production estimates.
 - a. Present production in hourly, daily, weekly, monthly intervals for year one; monthly and annual intervals over a 20-year time frame.
 - b. Utilizing historical TMY3 weather data from nearest NREL's weather station.
 - c. Assume a once annual cleaning of PV System modules.
 - d. Documentation of calculation assumptions (efficiencies, losses, etc.) used to derive the annual energy production estimate.
- F. Certify that products of this section meet or exceed specified requirements.
- G. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
- H. Manufacturer's detailed field-testing procedures.
- I. Manufacturer's detailed startup procedures.
- J. Rebate and incentive documentation.
- K. Utility interconnection documentation.
- L. Source quality control test reports.
- M. Field quality control test reports.
 - 1. Include manufacturer's field reports.
- N. Operation and Maintenance Data: Include the following as a minimum:
 - 1. Detailed information on system operation, equipment programming and setup.
 - 2. Replacement parts.
 - 3. Recommended maintenance procedures and intervals.

- 4. Contact information for entity that will be providing contract maintenance and trouble call-back service.
- O. Warranty: Submit sample of manufacturer's warranty and documentation of final executed warranty completed in Owner's name and registered with manufacturer.
- P. Maintenance contracts.
- Q. Project Record Documents:
 - 1. To include the following minimum information:
 - a. Plan view drawings of PV array(s) with serial number mapping for each module and each inverter.
 - b. Updated one-line diagrams including as a minimum:
 - 1) Conduit sizes and lengths.
 - 2) Conductor size and lengths.
 - 3) Identify PV source circuits, PV output circuits, and inverter input circuits.
 - c. Updated one-line diagrams of Rapid Shutdown system including as a minimum:
 - 1) System component with tags.
 - 2) System component locations.
 - 3) System cabling sizes and lengths.
- R. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Extra Photovoltaic Modules: Zero.

1.06 QUALITY ASSURANCE

- A. Comply with NFPA 70.
- B. Comply with Utility Company requirements for interconnection.
- C. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- D. Structural Designer Qualifications: Registered structural engineer licensed in the State in which the Project is located.
- E. Electrical Designer Qualifications: Registered electrical engineer licensed in the State in which the Project is located experienced in the design of photovoltaic systems.
- F. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- G. Installer Qualifications: Company specializing in performing the work of this section with minimum five years documented experience with photovoltaic systems of similar size, type, and complexity.
 - 1. Licensed in the State in which the Project is located to install photovoltaic systems.
 - a. Washington:
 - 1) Electrical Contractors License
 - 2. Manufacturer's authorized installer.
 - 3. Project Supervisor: North American Board of Certified Energy Practitioners (NABCEP) certified PV Installer or three years of experience supervising the installation of photovoltaic systems.
 - 4. Project Installation Personnel: At least 2 years of experience installing photovoltaic systems.
- H. Maintenance Contractor Qualifications: Same entity as installer or different entity with specified qualifications.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Protect equipment during shipping, handling, and storage to comply with the manufacturer's requirements and to prevent damage to the module glass.
 - 1. Damage to the module includes physical, condensation, temperature changes, sun, chemical, and other.

- B. Store products in manufacturer's unopened packaging, keep dry and protect from damage until ready for installation.

1.08 WARRANTY

- A. Specified warranties indicate minimum requirements. Provide additional warranties or extended warranty periods where required to qualify for rebate and incentive programs.
- B. Photovoltaic Modules:
 - 1. Provide minimum 25 year manufacturer warranty covering repair or replacement due to defective materials or workmanship.
 - 2. Provide manufacturer warranty guaranteeing minimum 94.7 percent of rated power output for 12 years and minimum 89.3 percent of rated power output for 30 years.
- C. Photovoltaic Module Mounting System: Provide minimum 20 year manufacturer warranty covering repair or replacement due to defective materials or workmanship.
- D. Photovoltaic Inverters: Provide minimum 10 year manufacturer warranty covering repair or replacement due to defective materials or workmanship.

PART 2 PRODUCTS

2.01 PHOTOVOLTAIC SYSTEM REQUIREMENTS

- A. Design and provide a complete photovoltaic system consisting of photovoltaic modules and associated balance of system components necessary for connection to facility electrical system.
- B. System Description:
 - 1. Photovoltaic array is (carport) and ground-mounted in locations indicated on the drawings.
 - 2. Tilt and azimuth of array is as indicated on the drawings.
 - 3. Photovoltaic DC system is ungrounded.
 - 4. System includes interconnection with utility grid (grid-tied system).
 - 5. System includes a battery storage system.
 - 6. System includes an engine generator (future).
 - 7. System includes a DC system surge protection.
 - 8. System includes an inverter based performance monitoring system.
 - 9. System includes a data acquisition and supervisory control provisions compatible with Microgrid Energy Management System.
 - 10. Owner intends to secure funds from available federal, state, and utility company rebate and incentive programs.
- C. Capacity:
 - 1. Minimum Expected Annual Energy Production: 138,400 kWh, as calculated by National Renewable Energy Laboratory's PVWatts calculator or approved equivalent.
 - 2. Total Nominal Rated Power Output of Array: Equal to or greater than the rated output of the basis of design array.
 - 3. Nominal Rated Power Output of Individual Modules: Equal to or greater than the rated output of the basis of design module.
- D. Physical Size:
 - 1. Array: Designed to fit within the area designated on the drawings.
 - 2. Individual Modules: Exact size as basis of design module.
- E. Appearance:
 - 1. Only systems with similar appearance to basis of design system will be considered.
 - 2. Arrange array such that modules are aligned with uniform spacing.
 - 3. Make no alterations affecting appearance of building exterior or interior without approval of Owner.
 - 4. Final determination of acceptable appearance is by Owner.

- F. Fire Resistance Rating: Provide photovoltaic module and mounting system combination that together with the roof covering form a system listed in accordance with UL 1703 to provide a fire rating equal to or better than the required fire rating of the roof.
- G. Provide photovoltaic system and associated components suitable for wind loads, snow loads, seismic loads, building seismic risk category and contraction of system components due to annual temperature fluctuations, and other structural design considerations of the installed location.
 - 1. Comply with ASCE 7.
 - 2. Include structural calculations demonstrating compliance with submittals.
- H. Provide photovoltaic system and associated components suitable for continuous operation under the service conditions at the installed location.
- I. Provide products listed, classified, and labeled as suitable for the purpose intended.
- J. Provide photovoltaic system and associated components that qualify for available federal, state, and utility company rebate and incentive programs.
- K. Unless specifically indicated to be excluded, provide required equipment, conduit, boxes, wiring, connectors, hardware, supports, accessories, software, system programming, etc. as necessary for a complete operating system.
- L. DC Arc Fault Circuit Protection: Provide DC photovoltaic arc-fault protection devices listed as complying with UL 1699B as required for compliance with NFPA 70.
- M. Rapid Shutdown of Photovoltaic Systems on Buildings: Provide listed equipment arranged and configured to provide UL 3741 compliant rapid shutdown with a single point of initiation in accordance with NFPA 70.
- N. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
 - 1. Where shading is unavoidable, minimize the negative impacts of shading from structures or other obstructions on PV system annual energy production by electrically isolating the PV source and output circuits associated with PV modules that are subject to localized shading from other modules within the array.
 - a. A shaded PV module is considered any PV module that is wholly or partially shaded from 9:00 AM to 3:00 PM for any day of the year.
 - b. A partially shaded module is any module that has more than half of its photovoltaically active surface in shade.

2.02 PHOTOVOLTAIC MODULES

- A. Manufacturers:
 - 1. Crystalline Silicon
 - a. Hanwha Q Cells
 - b. SilFab Solar
 - c. Heliene
 - d. Substitutions must be approved by Owner's Representative
 - 2. Bi-Facial
 - a. Hanwha Q Cells
 - b. SilFab Solar
 - c. Substitutions must be approved by Owner's Representative
- B. Acceptable Module Types: Only crystalline silicon modules are acceptable.
- C. General Requirements:
 - 1. Photovoltaic Modules: Factory assembled; consisting of photovoltaic cells, frame, junction box, cables for series connection, and bypass diodes for shade tolerance; rated for 1000V DC; complying with IEC 61215-1 and IEC 61215-2 and listed as complying with UL 1703.
 - 2. Crystalline Silicon Photovoltaic Modules:
 - a. Comply with IEC 61215-1-1.

- b. Photovoltaic conversion efficiency: 22.7% or greater.
- 3. Hail impact rating that meets or exceeds a Class-2 or higher rating per FM Approval Standard 4478, Rigid Photovoltaic Modules; or ANSI 4478, American National Standard for Rigid Photovoltaic Modules. At a minimum, the hail rating should be per IEC 61215 using a 45mm (1-3/4 inch) or greater ice ball.
- 4. Frame: Silver Anodized aluminum
- 5. Factory-Installed Junction Box: Weatherproof, with factory-installed terminals and bypass diodes.
- 6. Factory-Installed Cables: Type USE-2 or listed and marked photovoltaic (PV) wire with polarized locking connectors.
- 7. Unless otherwise indicated, specified module performance characteristics are rated under Standard Test Conditions (STC).
- 8. Power Rating Tolerance: Plus 10 or minus 0 percent.
 - a. Include flash test data for each module with source quality control reports to demonstrate compliance.

D. Basis of Design: SilFab SIL-540-XM Bifacial.

2.03 PHOTOVOLTAIC INVERTERS

- A. Manufacturers
 - 1. SolarEdge
- B. Provide inverter(s) as indicated or as required for connection of the photovoltaic array DC system to the AC system indicated.
- C. Inverters: Suitable for the requirements of the connected array; output configuration compatible with connected system; listed as complying with UL 1741-SB listed with an approved certification date on the California Energy Commission database of eligible inverters for California Rule 21 Phase 1, 2, and 3 grid interconnection requirements; furnished with the following features:
 - 1. Maximum power point tracking (MPPT).
 - 2. Integral DC disconnect(s).
 - 3. Integral DC ground fault detection and interruption (GFDI).
 - 4. Communications Interface:
 - a. As required for connection to system indicated.
 - b. Ethernet communications card as required to provide supervisory control and data acquisition to each inverter.
 - c. Bi-directional, SunSpec compliant, communication over the following protocols to a third-party monitoring and control system.
 - 1) MODBUS TCP
 - 2) IEEE 2030.5
 - 5. The inverter is capable of operating unattended in an automatic pre-programmed failsafe mode.
 - 6. Display screen or ability to connect display screen to provide read-out of operational system states, input, and output voltages, AC currents, wattage, etc., and permit local programming control of the inverter.
- D. Grid-Tied Inverters: Comply with IEEE 1547-2018, including over/under grid voltage and frequency protection, and anti-islanding protection to automatically disconnect upon loss of utility power and to remain disconnected until utility power restoration has been maintained for five minutes.
- E. Total Harmonic Distortion: Less than five percent.
- F. Enclosure Environment Type per NEMA EN 10250: Unless otherwise indicated, as specified for the following installation locations:
 - 1. Outdoor Locations: Type 3R.

2.04 PHOTOVOLTAIC MODULE POWER OPTIMIZER

- A. Manufacturers
 - 1. SolarEdge
- B. General Requirements:
 - 1. Efficiency: 99.5%
 - 2. Module-level monitoring capability.
 - 3. Module-level voltage shutdown.
 - 4. Meets NEC requirements for arc fault protection (AFCI).
 - 5. Meets NEC requirements for Photovoltaic Hazard Control System (PVHCS).

2.05 PHOTOVOLTAIC MODULE MOUNTING SYSTEM

- A. Manufacturers
 - 1. Ground Mount Canopy System
 - a. Terrasmart
 - b. Baja Carports
 - c. Kern Solar Structures
 - d. M Bar C Construction
 - e. RBI Solar
- B. Provide complete mounting system compatible with modules installed and suitable for proper installation in the location indicated, including necessary hardware and accessories.
- C. Support Structure and Associated Hardware Materials: Use aluminum or galvanized steel.
- D. Ground-Mounted Arrays:
 - 1. Configuration: As indicated on Design Drawings.
 - 2. Foundation Type: As required for soil conditions at installed location.

2.06 BALANCE OF SYSTEM COMPONENTS

- A. Manufacturers
 - 1. AC Combiner Panel
 - a. Use the same manufacturer as the distribution equipment specified in Section 26 24 16 - Panelboards.
 - 2. Surge Protection Devices
 - a. Use the same manufacturer as the equipment specified in this Section.
 - b. Rated for 1000 DC.
 - c. Listed and labeled as complying with UL 1449, Type 1.
 - d. Surge current rating not less than 50 kA per mode.
 - e. UL 1449 Nominal discharge current (I-n): 20kA.
- B. AC Combiner Panel: Comply with Section 26 24 16 - Panelboards.
- C. Enclosed Switches, in Addition to Requirements of Section 26 28 16.16 - Enclosed Switches:
 - 1. Switches for DC System: Rated for 1,000V DC.
 - 2. Switches Connected to Supply Side of Service Disconnecting Means: Listed and labeled as suitable for use as service equipment according to UL 869A.
- D. Batteries: Comply with Section 26 33 63 - Battery Energy Storage System.
- E. Molded-Case Circuit Breakers and Switches for DC System: Rated for 1,000 V DC; listed as complying with UL 489B.
- F. Additional Requirements of Section 26 28 13 - Fuses:
 - 1. Fuses for DC System: Rated for 1,000V DC.
 - 2. Fuses for Protection of Photovoltaic Strings and Arrays: Photovoltaic fuses listed as complying with UL 2579 .

2.07 PV SYSTEM PERFORMANCE MONITORING

- A. Manufacturers

1. SolarEdge
- B. Provide system to monitor photovoltaic system performance including sensors, dataloggers, connections, software, equipment, and accessories necessary for a complete operating system.
- C. System communications interfaces to be wired, with compatible interconnected components.
 1. Provide suitable raceway, minimum 3/4-inch trade size, for required wired connections.
- D. System to monitor and record, in 15-minute intervals:
 1. Inverter status.
 2. Inverter Instantaneous power (kW).
 3. Inverter Cumulative energy production (kWh).
- E. Energy Production Meter: Revenue grade, accuracy of plus or minus two percent.
- F. System real-time and historical data to be accessible from the following locations:
 1. Personal computer(s), via internet connection.
- G. System to provide alarm notification via e-mail or instant (SMS) message.
- H. System to be compatible with third party monitoring service to be selected by Owner.
- I. System to be compatible with microgrid energy management system via communication protocol as agreed upon with MEMS control vendor.

2.08 PV SYSTEM REMOTE SUPERVISORY CONTROL AND DATA ACQUISITION

- A. System to provide supervisory control and data acquisition capability for the photovoltaic inverter(s) operation via the following protocols to the Microgrid Energy Management System:
 1. SunSpec compliant MODBUS/TCP
 2. IEEE 2030.5

2.09 SOURCE QUALITY CONTROL

- A. Source Limitations: For each type of component, furnish products produced by a single manufacturer and obtained from a single supplier.
- B. Factory test the following products to verify operation and performance characteristics. Include test reports with submittals.
 1. Photovoltaic modules.
 2. Photovoltaic inverters.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify field measurements are as indicated.
- B. Verify ratings and configurations of system components are consistent with the indicated requirements.
- C. Verify mounting surfaces are ready to receive system components.
- D. Verify conditions are satisfactory for installation prior to starting work.

3.02 PREPARATION

- A. Use open circuiting, short circuiting, or opaque covering to disable modules, array or portions of array prior to installation and service.
- B. Roof-Mounted Arrays: Protect roof and adjacent roof-mounted items from damage.

3.03 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Install photovoltaic system in accordance with NECA 412.
- D. Provide required support and attachment in accordance with Section 26 05 00.

- E. Mount equipment such that the highest position of operating handle for circuit breakers or switches does not exceed 79 inches above the floor, ground, or working platform.
- F. Provide cast-in-place concrete foundations for ground-mounted arrays as indicated.
- G. Foundation-Mounted Poles for Pole-Mounted Arrays:
 - 1. Provide cast-in-place concrete foundations for poles as indicated.
 - a. Install anchor bolts plumb per template furnished by pole manufacturer.
 - b. Position conduits to enter pole shaft.
 - 2. Install foundations plumb.
 - 3. Install poles plumb, using leveling nuts or shims as required to adjust to plumb.
 - 4. Tighten anchor bolt nuts to manufacturer's recommended torque.
 - 5. Install non-shrink grout between pole anchor base and concrete foundation, leaving small channel for condensation drainage.
 - 6. Install anchor base covers or anchor bolt covers as indicated.
 - 7. Embedded Poles for Pole-Mounted Arrays: Install poles plumb as indicated.
- H. Circuiting Requirements, in Addition to Requirements of Section 26 05 00.:
 - 1. Wiring Methods:
 - a. Unless otherwise indicated, use exposed module factory-installed cables (not routed inside building) for module interconnections.
 - b. Unless otherwise indicated, use exposed type USE-2/RHH/RHW-2 single-conductor cable or listed photovoltaic wire (not routed inside building) for wiring between string(s) and combiner box(es).
 - c. Unless otherwise indicated, use type THHN/THWN-2 single-conductor building wire in suitable raceway for wiring between combiner box(es) and point of interconnection.
 - d. Secure exposed cables in accordance with NFPA 70. Where possible, conceal behind array.
 - e. Install cables in suitable raceway where readily accessible or where required by authority having jurisdiction.
 - f. Use suitable twist-on insulated spring connectors, mechanical connectors, or compression connectors for photovoltaic circuit splices and taps.
 - 2. Photovoltaic DC System Conductor Color Code:
 - a. Ungrounded System:
 - 1) Positive: Red.
 - 2) Negative: Black.
 - 3. Maintain separation of photovoltaic and non-photovoltaic circuits in accordance with NFPA 70.
- I. Grounding and Bonding Requirements, in Addition to Requirements of Section 26 05 00 - Grounding and Bonding for Electrical Systems:
 - 1. Ensure that there is only one AC System bonding connection between grounding system and grounded/neutral conductor, including external connections and connections internal to equipment.
 - 2. Grounded DC Systems: Ensure that there is only one point of system grounding connection to the grounded conductor, including external connections and connections internal to equipment.
 - 3. Provide auxiliary electrodes for photovoltaic array grounding in accordance with NFPA 70.
- J. Identification Requirements, in Addition to Those Specified in Section 26 05 00. :
 - 1. Color for Photovoltaic System Identification Nameplates and Labels: White text on red background, unless otherwise required by NFPA 70 or authorities having jurisdiction.
 - 2. Use identification nameplate or means of identification acceptable to authority having jurisdiction to identify the presence of multiple power sources and the location of main service disconnecting means and each photovoltaic system disconnecting means. Locate at main service disconnecting means and at each photovoltaic system disconnecting means. Verify format and descriptions with authorities having jurisdiction.

3. Use identification nameplate to identify each photovoltaic system disconnecting means with text "PV SYSTEM DISCONNECT".
4. Use identification nameplate or identification label to identify systems equipped with rapid shutdown and associated rapid shutdown switch(es). Format, descriptions, and locations to comply with NFPA 70 and requirements of authorities having jurisdiction.
5. Use identification nameplate or identification label to identify the information required by NFPA 70 for marking of direct-current photovoltaic power sources. Locate at each DC disconnect means requiring marking.
6. Use identification nameplate or identification label to identify the interactive system point of interconnection at the disconnecting means as a power source and with the rated AC output current and the nominal operating AC voltage.
7. Where the inverter output connection is located in a panelboard on the opposite (load) end from the input feeder location or main circuit location in order to meet requirements of NFPA 70, use identification nameplate or identification label to identify the overcurrent device with the word message "Warning; Inverter output connection; Do not relocate this overcurrent device".
8. Use warning labels to identify electrical hazards for photovoltaic system disconnecting means. Include the word message "Warning - Electric Shock Hazard; Terminals on the line and load sides may be energized in the open position" or approved equivalent.
9. Use warning labels, identification nameplates, or identification labels to identify electrical hazards for photovoltaic systems equipped with DC ground-fault protection in accordance with NFPA 70. Include the word message "Warning - Electric Shock Hazard; If a ground fault is indicated, normally grounded conductors may be ungrounded and energized".
10. Use wire and cable markers to identify photovoltaic system source, output, and inverter circuit conductors at points of termination, connection, and splices.
11. Use voltage markers, identification labels, stenciled text, or suitable permanent marking approved by authority having jurisdiction to identify exposed raceways, cable trays, pull boxes, junction boxes, and conduit bodies with the text "Warning: Photovoltaic Power Source" at maximum intervals of 10 feet in accordance with NFPA 70.

3.04 FIELD QUALITY CONTROL

- A. See article "SYSTEM STARTUP" below for additional requirements related to testing and inspection.
- B. Provide services of a manufacturer's authorized representative to observe installation and assist in inspection and testing. Include manufacturer's detailed testing procedures and field reports with submittals.
- C. Inspection and testing to include, at a minimum:
 1. Inspect each system component for damage and defects.
 2. Verify that equipment enclosures, boxes, and associated connections installed outdoors are weatherproof.
 3. Verify proper wiring connections have been made and check for conductor continuity. Verify proper polarity.
 4. Verify tightness of mechanical and electrical connections are according to manufacturer's recommended torque settings.
 5. Perform insulation resistance tests.
 - a. Disconnect surge protective devices (SPDs) prior to performing high potential testing. Replace SPDs damaged by performing high potential testing with SPDs connected.
 6. Measure and record ambient conditions, including date and time, ambient temperature, cell temperature, solar irradiance in the module plane, and wind speed.
 7. Measure and record open circuit voltage of each string.
 8. Measure and record operating current for each string, sub-array, and array.
 9. Verify proper operation of monitoring system.
- D. Correct defective work, adjust for proper operation, and retest until entire system complies with Contract Documents.

- E. Diagnostic Period: After successful completion of inspections and tests, operate system in normal mode for at least 14 days without system or equipment malfunctions.
 - 1. Record system operations and malfunctions.
 - 2. If a malfunction occurs, start diagnostic period over after correction of malfunction.
- F. Submit detailed reports indicating inspection and testing results and corrective actions taken.
- G. Repair roof or adjacent roof-mounted items damaged as a result of work of this section.

3.05 SYSTEM STARTUP

- A. Provide services of a manufacturer's authorized representative to assist in performing system startup. Include manufacturer's detailed startup procedures with submittals.
- B. Obtain Owner's approval prior to performing system startup.
- C. Grid-Tied Systems: Obtain Utility Company's approval prior to performing system startup.
- D. Prepare and start system in accordance with manufacturer's instructions.
- E. After the installation and initial start-up of the PV System is complete, perform a test and log in the presence of the Owner. Provide an engineer to monitor the system during the tests, to check details of the installation and to instruct the operators. This engineer will be required for a period of not less than 2 days for instruction and tests. Include the cost for this engineering service in the Contractor's bid. Furnish instruments to conduct the tests and connect devices required to obtain data required.
- F. Field Test Requirements:
 - 1. Record data and results as required to prepare the Commissioning Report submittal as detailed in Section 3.5.G.
 - 2. Additional test data include:
 - a. Test the AC line voltage at PV system AC disconnect(s) to confirm that it is within 2 percent of system rated line to line and line to ground voltage. Record voltage data.
 - b. Test the continuity of DC fuses (if applicable) to be installed in each DC string combiner box.
 - c. Test PV array open circuit DC voltage at each inverter DC disconnect switch to ensure voltage is within proper limits according to the inverter manufacturer's installation manual.
- G. PV System Commissioning Report:
 - 1. Provide a commissioning report that conforms to the SunSpec Alliance Best Practices Guide for Commissioning for PV Performance (D42039-1).
 - 2. Include the following sections with associated data and results:
 - a. PV system information and data collected at time of commissioning:
 - 1) System name, address location.
 - 2) System size, type (fixed, tracking), module, inverter, pitch, and azimuth.
 - 3) As-built system derate factors:
 - (a) DC wiring loss.
 - (b) Power optimizer loss (if applicable).
 - (c) AC wiring loss.
 - (d) Step-up transformer loss (if applicable).
 - 4) Name of person(s) performing the tests and reporting the results.
 - 5) Test equipment used (monitoring/model, irradiance sensor, temperature sensor, etc.)
 - 6) Period of time for measurements.
 - 7) Number of measurements taken and used.
 - 8) Irradiance measured (and conversion of POA to GHI if appropriate).
 - 9) Temperature measured (and conversion of ambient to module/cell if appropriate).
 - 10) AC power measured.

- b. Calculation of the Power Performance Index (PPI) and associated findings:
 - 1) Calculation method and associated system derate factors used to calculate PPI.
 - 2) PPI calculated (measured kWac to expected kWac).
 - 3) Uncertainty of the test results and acceptable tolerances.
 - 4) Notes on significant findings or observances.
 - 5) Summary and narrative of the outcome, with an action plan, if required.

3.06 CLEANING

- A. Clean modules using only methods recommended by manufacturer to avoid scratches and other damage. Clean exposed surfaces on other components to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.07 CLOSEOUT ACTIVITIES

- A. Demonstration: Demonstrate proper operation of system to Owner, and correct deficiencies or make adjustments as directed.
- B. Training: Train Owner's personnel on operation, adjustment, and maintenance of photovoltaic system.
 - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
 - 2. Walk-thru of the installed and operational PV equipment identifying the function and maintenance requirements for each component.
 - 3. PV system status monitoring and configuration capabilities and methods for local and remote access to monitoring and configuration utilities.
 - 4. Review of PV System O&M binder materials.
 - 5. Supervised control of PV system operation by authorized Facility Owner personnel.
 - a. At a minimum, place the PV system into standby mode, perform a complete maintenance shutdown (de-energization) of the PV system, perform a complete energization of the PV system and place the PV system into normal run mode following a standby command.
 - 6. Provide minimum of four hours of training.
 - 7. Instructor: Inverter manufacturers authorized representative who is thoroughly knowledgeable of the specific installation.
 - 8. Location: At project site.

3.08 PROTECTION

- A. Protect installed products from subsequent construction operations.

3.09 MAINTENANCE

- A. Provide to Owner, a proposal as an alternate to the base bid, a separate maintenance contract for the service and maintenance of photovoltaic system for two years from date of Substantial Completion, to include the work described below; Include a complete description of preventive maintenance, systematic examination, adjustment, cleaning, inspection, and testing, with a detailed schedule.
- B. Conduct site visit at least once every six months to perform inspection, testing, and preventive maintenance. Conduct tests similar to those made during original field quality control testing. Submit report to Owner comparing test results with those of original tests along with evaluations and recommendations.
- C. Provide trouble call-back service upon notification by Owner:
 - 1. Include allowance for call-back service during normal working hours at no extra cost to Owner.
 - 2. Owner will pay for call-back service outside of normal working hours on an hourly basis, based on actual time spent at site and not including travel time; include hourly rate and definition of normal working hours in maintenance contract.

END OF SECTION 26 31 00

SECTION 26 33 63.16
BATTERY ENERGY STORAGE SYSTEM OUTDOOR

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Outdoor Battery Energy Storage System (BESS)
 - 1. Electrochemical batteries for stationary energy storage
 - 2. Battery Power Conversion System (PCS)
 - 3. Battery Management System (BMS)
 - 4. Battery Plant Level Controller (BPLC)
 - 5. Modular BESS enclosures rated for exterior use
 - 6. Isolation transformer(s)
 - 7. BESS enclosure HVAC equipment
 - 8. BESS enclosure fire detection and suppression
 - 9. Early off-gas detection system
- B. Installation of BESS as a complete system fully integrated into the facility electrical system.
- C. Component Functional Acceptance Testing
- D. System Commissioning
- E. Factory Tests
- F. Battery Energy Storage System (BESS) operational functions include:
 - 1. Economic optimization of facility electrical energy and power consumption.
 - 2. Optional standby electrical power in conjunction with a Microgrid Energy Management System (MEMS).
 - 3. On-site renewable energy self-consumption.
 - 4. Electrical utility maximum export management in conjunction with a Microgrid Energy Management System (MEMS).

1.02 WORK INCLUDED

- A. Provide complete BESS as described below and as indicated on the Drawings:
 - 1. Self-contained BESS, UL listed as a system including battery energy storage modules, BMS, BPLC, PCS hardware, NEMA 3R or 4 rated enclosure(s), overcurrent protection, HVAC equipment, off-gas detection system, fire detection and suppression system.
 - 2. Battery string combining and disconnecting equipment may be integral to BESS or provided additionally as required by Code.
 - 3. Off-gas detection system may be integral to BESS product or provided additionally.
 - 4. Provide associated power and communications wiring required for a complete and operational system.
 - 5. Integrated into the facility electrical system without impact to the utility service or power quality and in-compliance with applicable Codes, manufacturer and electrical utility requirements.
 - 6. Integrate BESS thermal runaway status (via BMS), off-gas detection, fire detection and suppression system(s) alarms into Facility Fire Alarm system(s) as required by local Authority Having Jurisdiction (AHJ).
 - 7. Provide labeling as required by the local AHJ.
 - 8. Provide Hazard Mitigation Analysis (HMA) as required by the local AHJ.
 - 9. Commissioning of BESS by manufacturer technician or manufacturer trained technician includes testing and verification of charge and discharge cycles under all modes of operation.
 - 10. Coordination with MEMS design-build contractor to ensure successful integration of BESS into facility MEMS control topology.

1.03 REFERENCE STANDARDS

- A. Publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designations only.
 - 1. Institute of Electrical and Electronics Engineers (IEEE)
 - a. IEEE 1547 Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces
 - b. IEEE 519 Recommended Practice and Requirements for Harmonic Control in Electric Power Systems
 - c. IEEE 693 Recommended Practice for Seismic Design of Substations
 - 2. International Electrotechnical Commission
 - a. IEC 61850 Communication Networks and Systems for Power Utility Automation
 - 3. International Fire Code (IFC)
 - a. IFC 608 (2015) Stationary Storage Battery Systems
 - b. IFC 1206.2 (2018) Electrical Energy Storage Systems
 - 4. National Electric Code (NEC)
 - 5. National Fire Protection Association (NFPA)
 - a. NFPA 855 Installation of Stationary Energy Storage Systems
 - 6. Underwriters Laboratory (UL)
 - a. UL1642 Standard for Lithium Batteries
 - b. UL1973 Batteries for Use in Stationary, Vehicle Auxiliary Power and Light
 - c. UL2775 Fixed Condensed Aerosol Extinguishing System Units
 - d. UL61010-1 Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use
 - e. UL9540 Energy Storage Systems and Equipment
 - f. UL9540A Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems
 - g. UL1741sb (3rd Edition) Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination
 - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment or other potential obstructions within the spaces dedicated for BESS.
 - 2. Coordinate arrangement of equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 3. Coordinate the work to provide electrical circuits suitable for the power requirements of the actual auxiliary equipment and accessories to be installed.
 - 4. Notify Project Engineer of conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Preinstallation Meetings
 - 1. Convene one week before starting work of this section; require attendance of equipment vendor and all affected equipment installers.

1.05 DEFINITIONS

- A. Battery Energy Storage System (BESS):
 - 1. BESS denotes a stationary battery energy storage system consisting of single or multiple cabinets with battery energy storage modules and cells, integral battery management system (BMS), and power conversion system (PCS) to import and export energy from the local electrical power system, and weatherproof enclosure. Provide pre-engineered and prepackaged system to relieve strict spatial requirements as required by local codes and jurisdictions.
- B. Power Conversion System (PCS):

1. PCS denotes an enclosed unit consisting of solid-state power conversion electronics that perform rectification of local electrical power system AC power to DC power for storage by the BESS battery modules and an inverter stage that converts stored battery module DC power to AC power.
- C. Battery Management System (BMS):
 1. Electronic system integral to BESS managing rechargeable battery modules to ensure batteries are maintained within a safe operating region for parameters such as voltage, current, temperature and pressure. Provides active thermal runaway detection and prevention.
- D. Battery Plant Level Controller (BPLC)
 1. Electronic monitoring and supervisory control system provided with the BESS serving to ensure safe operation of BESS and PCS as single controllable entity.
 2. Exclusive point of interface for supervisory control between BESS, including PCS and host facility or site.

1.06 SUBMITTALS

- A. Accompanying the bid, provide information submitted for evaluation:
 1. Evaluation form accompanying bid form.
 2. Product data sheets for equipment variants supplied to Project.
 3. System one-line diagram showing components supplied, interconnections supplied, field wiring required to interconnect components, and other pertinent information.
 4. Equipment plan and elevation drawings showing dimensions of enclosures and required clearances.
 5. UL9540 listing certification.
- B. Within 45 days from receipt of signed purchase order, provide information submitted for evaluation:
 1. Complete Product Data
 - a. UL9540A large scale fire test data reports for cell level, module level and unit level (if required).
 2. Shop Drawings
 3. Factory Test Reports
 4. Spare Parts List
 5. System Coordination Drawings
 - a. Identify system components and interconnecting cables.
 - b. Include terminal numbers on equipment, the size, type and numbers (corresponding to drawings) of cables and wires.
 6. Installation drawings, including outlines, floor loading and details for securing equipment.
 7. Include recommended maintenance schedule including description and frequency of tests and recommend parts replacement schedule.
 8. Control wiring diagrams and instructions for control interoperability.
 9. Control registers (ie: points list) including control syntax examples.
- C. Provide manufacturer's detailed specifications and data sheets to fully describe equipment furnished. Specifically note deviations from the Specifications within submittal. Failure to comply will automatically void any implied approval for use of equipment on this project.
- D. Review and recommendations by the Engineer are not to be construed as change authorizations. If discrepancies between the materials or equipment submitted and the Specifications are discovered prior to or after the data is processed, the Specifications will govern.

1.07 CLOSEOUT SUBMITTALS

- A. Provide complete Operating Instructions and Maintenance Manuals submittal prior to substantial completion of the project.

- B. Provide outline of on-site system demonstrations and training to be provided by manufacturer to owner and owner representative. Indicate time period required for the owner training.
- C. Collect system start-up test reports as required under Part 3 of this Section.

1.08 QUALITY ASSURANCE

- A. Manufacturer:
 - 1. Regularly engaged in manufacture of solid-state power conversion equipment and energy storage equipment for commercial and industrial use.
 - 2. Maintain quality control program encompassing in-process as well as final inspection and tests designed to ensure quality, reliability, and performance required by this specification.
- B. Acceptance Tests:
 - 1. Factory testing for equipment furnished under this specification:
 - a. Complete wire check to assure correct connections and quality of joints and terminations.
 - b. Grounding check of complete system equipment.
 - c. Electrical operation of control circuits.
 - d. Safety check for spacing of bare bus bars, conductors, and components and for access space for maintenance.
 - e. Static and magnetic noise elimination check to avoid control circuit interference.
 - f. Further testing as required under Part 3 of this Section.
 - g. Provide manufacturer documentation indicating successful completion of outlined testing.

1.09 WARRANTY

- A. Provide manufacturer's written warranty for supplied equipment.
- B. Provide a written warranty covering the work done under this Section as required by the General Conditions. Regardless of other requirements of the General Conditions, minimum warranty period for the Electrical work for one year after start-up and beneficial use by the Owner.
 - 1. Equipment and Systems:
 - a. Free of defects of material and workmanship and in accord with the Contract Documents.
 - b. Built and installed to deliver its full rated capacity at the efficiency for which it was designed.
 - c. Operate at full capacity without objectionable noise or vibration. Objectionable noise is that which greater than levels listed in these Specifications; greater than the levels listed in NEMA standards, or greater than that produced by similar equipment on site.
 - 2. Systems: Include system damage caused by failures of any system component.
- C. Provide warranty under this scope of work limited to the work provided under this contract.

PART 2 PRODUCTS

2.01 OUTDOOR BESS

- A. Commercial Manufacturers
 - 1. ELM Microgrid
- B. System Components & Ratings
 - 1. Battery Energy Storage System (BESS)
 - a. Minimum energy storage capacity (kWh) as indicated on the Drawings.
 - b. DC System Voltage: 700VDC to 1,500VDC
 - 1) Lower DC system voltages are permitted for Residential installations.
 - c. Capable of continuously sustaining charging or discharging power (kW) equal or greater than the interconnected PCS nameplate power rating.
 - d. Minimum charging C-rate range of 0.5 C.
 - e. Minimum discharging C-rate range of 0.5 C.

- f. Depth of Discharge: Greater than 90 percent.
 - g. Cycle Life: Minimum 4,000 cycles.
 - h. Calendar Life: Minimum 15 years.
 - i. AC Round-Trip Efficiency: Minimum 90 percent.
 - j. Audible noise to be less than or equal to 65dBA at 5 feet.
 - 1) Do not exceed 55 dBA when measured at property line.
 - 2) Notify Project Engineer immediately if alternate BESS equipment siting is required to satisfy sound level requirements.
 - k. Certifications & Standard Compliance
 - 1) UL9540
 - 2. Electrochemical Battery Modules
 - a. Battery Chemistry:
 - 1) Lithium Iron Phosphate, LiFePO4 (LFP)
 - b. Certifications & Standard Compliance
 - 1) UL1973
 - 3. Power Conversion System (PCS)
 - a. Power rating as indicated on Drawings.
 - b. Overload Power Capacity: 120% of nominal.
 - c. AC Interconnection Voltage: As indicated on Drawings.
 - 1) Voltage Tolerance Range: ± 10 percent
 - d. DC Voltage: To match BESS DC bus voltage.
 - e. Frequency: 60 Hz
 - 1) Frequency Tolerance Range: ± 5 percent
 - f. Power Factor: -1.0 (leading) to 1.0 (lagging) for 0 to 100 percent load at ± 10 percent input voltage.
 - g. THD: less than 5%
 - h. AC fault current contribution to be minimum 800% of nominal FLA for 24 cycles.
 - i. Fully controllable four-quadrant operation
 - j. Efficiency: 97.0% (California Energy Commission listed)
 - k. Capable of operating in both Grid Following (CSI) and Grid Forming (VSI) modes.
 - 1) CSI to VSI Transition Time: Less than 2 cycles (0.033 seconds)
 - l. Certifications & Standard Compliance
 - 1) UL1741 SA/SB
 - 2) IEEE 1547
 - 3) IEEE 519
 - 4) CA Rule 21
 - 5) HI Rule 14H
 - m. Integral lockable disconnecting means to separate the AC output terminals (interface with local electrical power system) from the local electrical power system.
 - 4. Isolation Transformer
 - a. Serve as source for unbalanced phase current (neutral return path) with respect the facility electrical power distribution system when facility is islanded.
 - b. Additional requirements per Section 26 22 00 - Low-Voltage Transformers
 - 5. Battery Management System (BMS)
 - a. Battery group level BMS includes communications to local BESS plant level controller to facilitate safe BESS operation and fail-safe shutdown of BESS modules under abnormal operating conditions.
 - b. Battery group level BMS includes switching provisions to disconnect a battery module or module rack if battery module is operated outside of its safe operating region.
 - c. Battery group level BMS completely pre-wired and tested by BESS manufacture to ensure fail-safe operation of battery modules. No field connections or wiring to BMS to be required or permitted for successful operation of BESS or integration into facility electrical power system.

- d. Each BESS array monitored by the BMS to have capacity no greater than 50 kWh.
- e. Provide BMS power from the BESS DC system bus or external source of uninterruptible power to ensure uninterrupted communications and system monitoring for a minimum of 15 minutes during a utility power outage.
- 6. Battery Plant Level Controller (BPLC)
 - a. BPLC to be controllable via one or more of the following protocols without the need for external protocol conversion boxes:
 - 1) Modbus/TCP
 - 2) IEEE 2030.5
 - 3) DNP3
 - 4) IEC 61850
 - 5) JSON
 - b. BPLC to receive power supply from the BESS DC system bus or an external source of uninterruptible power to ensure continuous system communications and monitoring for a minimum of 15 minutes during a utility power outage.
 - c. Provide BPLC explicitly approved for use by the BESS manufacturer.
- 7. Battery Enclosure
 - a. Modular free-standing enclosure system listed for outdoor operation and inclusive of battery module racks, mounting provisions.
 - b. Satisfying the seismic bracing requirements of Section 260548 - Vibration and Seismic Controls for Electrical Systems.
 - c. Provide NEMA 3R or NEMA 4 rated eEnclosure.
- 8. BESS Balance of System
 - a. Integral DC over-current protection and disconnecting means to electrically disconnect each battery cabinet from the BESS DC system bus.
 - b. Integral Off-Gas Sensing & Thermal Runaway Prevention:
 - 1) Each battery array (rack, cabinet, module cluster, etc.) within the BESS to include a gas detector that is capable of detecting gas species that are byproduct of a module off-gas event prior to module thermal runaway. Upon detection of off-gas event, announce a system trouble alarm to the facility FACP, safely shut down BESS, and initiate a switchover to full exhaust of the BESS ventilation system if so equipped.
 - 2) Each monitored BESS group to have capacity no greater than 50 kWh.
 - 3) Off-Gas Sensing system to be provided by the BESS manufacturer via integration at the factory.
 - 4) Off-Gas Sensing Products:
 - (a) Basis of Design Manufacturer: Li-ION Tamer
 - (b) Or Approved Equivalent
 - (1) Substitutions: See Section 01 60 00 - Product Requirements
 - c. Integral surge protection.
 - d. HVAC
 - 1) Internally powered and pre-wired at factory. No auxiliary power connections required for power cabinet heating, ventilation and cooling system power.
- C. Operation Characteristics
 - 1. BPLC dispatches BESS based on pre-programmed utility rate tariff schedules, time-clock schedules, grid carbon intensity schedules or connected real-time power metering device to provide grid-connected generation or consumption of real and reactive electrical power with the PCS in grid-following mode (CSI).
 - a. PCS capable of establishing dispatch priorities and co-optimizing for multiple operational objectives.
 - 2. BPLC to prevent BESS operation under unsafe system or ambient conditions.
 - 3. BPLC serves as a single point for remote supervisory control and data acquisition of BESS.

4. PCS converts local electrical system AC power to DC power for storage by the BESS.
5. PCS converts the DC BESS power into real and reactive AC power delivered to or received from the local electrical power system.
6. MEMS Interactive Operation
 - a. BPLC responds to MEMS control signals to provide generation or consumption of real and reactive electrical power with the PCS in either grid-following (CSI) or grid-forming modes (VSI).
 - b. BPLC serves as a single point of supervisory control to safely operate BESS based on external dispatch commands from MEMS.
 - c. BPLC provides MEMS with summary level information of BESS plant status to inform MEMS real-time dispatch strategy.
- D. Environmental Performance
 1. Capable of withstanding any combination of the following external environmental conditions without mechanical or electrical damage or degradation of operating characteristics:
 - a. Operating ambient temperature -4 degrees Fahrenheit to 120 degrees Fahrenheit.
 - b. Relative humidity 0 percent to 98 percent for temperatures in the temperature range stated above.
 - c. Barometric Pressure: From sea level to 3,000 feet above sea level without derate.
- E. Control & Monitoring
 1. BESS Status and Operator Control:
 - a. Local digital display of system operational parameters via integral touchscreen.
 - b. Password protected system control.
 2. BESS Monitoring:
 - a. BESS to include, at a minimum, provisions for acquisition, data storage, recall and display of the following operational parameters:
 - 1) PCS output voltage for each phase
 - 2) PCS output current for each phase
 - (a) Charging currents to be negative values
 - 3) PCS export power (real, reactive, apparent)
 - (a) Charging power to be negative values
 - 4) DC battery voltage (PCS input voltage)
 - 5) DC charge/discharge current
 - (a) Charging currents to be negative values
 - 6) Battery module state of charge and/or depth of discharge
 - 7) BESS stored energy
 - (a) Total system energy
 - (b) Module level stored energy
 - (c) Remaining system runtime at present power demand
 - 8) Battery charge cycles
 - 9) Battery operating temperature
 - 10) System Fault Alarms
 - b. BESS to have capabilities via BPLC for remote monitoring of system parameters.
 3. Communications:
 - a. BPLC serves as a single point for remote supervisory control and data acquisition of BESS.

PART 3 EXECUTION

3.01 INSPECTION

- A. After the equipment has arrived at the job site, Owner, Engineer, and Manufacturer's Representative to perform visual inspection for physical damage and compare nameplate data with drawings and specifications.

- B. Correct problems encountered and documented by Owner, Engineer and Manufacturer's Representative.

3.02 INSTALLATION

- A. Install BESS and PCS equipment, associated cabinets, BESS appurtenances and make wiring connections per manufacturer's recommendations.
- B. Provide seismic anchoring/restraints of raceway and equipment in accordance with:
 - 1. 260529 - Hangers and Supports for Electrical Systems.
 - 2. 260548 - Vibration and Seismic Controls for Electrical Systems.
- C. Control and Communication Raceways
 - 1. Contractor to provide controls and communications cabling and associated raceway systems between the BESS and following components or building/facility systems:
 - a. Fire Alarm Control Panel.
 - b. Building Automation System (BAS).
 - c. Microgrid Energy Management System.
 - d. Utility Demand Response Controller.
 - e. SCADA.
 - f. Facility Ethernet system in Main Distribution Frame (MDF) or local Intermediate Distribution Frame (IDF).
 - 2. Additional communications and controls cabling and raceway provisions as indicated on Drawings.

3.03 FIELD QUALITY CONTROL

- A. Engage factory-trained field service personnel to perform the following inspections and test procedures during the BESS start-up testing, Owner, Engineer, Manufacturer's Representative and Contractor will include inspection and documentation of the following:
 - 1. Visual Inspection:
 - a. Inspect equipment for signs of damage.
 - b. Verify installation per Drawings.
 - c. Inspect cabinets for foreign objects.
 - d. Verify neutral and ground conductors are properly sized and configured.
 - e. Inspect cell cases.
 - f. Inspect each cell for proper polarity.
 - g. Verify printed circuit boards are configured properly.
 - 2. Mechanical Inspection:
 - a. Check control wiring connections for tightness.
 - b. Check power wiring connections for tightness.
 - c. Check terminal screws, nuts, and/or spade lugs for tightness.
 - 3. Electrical Inspection:
 - a. Check fuses/breakers for continuity.
 - b. Confirm input and bypass voltage and phase rotation is correct.
 - c. Verify control transformer and/or integral power supply connections (if present) are correct for voltages being used.
 - d. Assure connection and voltage of battery string(s).
 - e. Facilitate inspections and test procedures designated under equipment purchase contract.

3.04 START-UP TESTING

- A. Perform manufacturer approved start-up test procedures by factory-trained field service personnel.
- B. Start-Up tests witnessed by Owner or Owner's representative, Contractor and Project Electrical Engineer.
- C. Capacity and Burn-In Test:

1. Discharge Testing Parameters:
 - a. PCS full load, 0.8 power factor, 77°F maximum ambient room temp.
 - b. Loading time 48 hours, minimum (2 hours at 77°F maximum ambient room temp).
 - c. Record actual loads in KW, power factor, temperatures, and total time in hours, as part of record.
 2. Charging Testing Parameters:
 - a. PCS full charge capacity, 77°F maximum ambient room temp.
 - b. Record actual loads in KW, power factor, temperatures, and total time in hours, as part of record.
- D. PCS Discharge Performance Tests:
1. Phase Balanced Testing Parameters:
 - a. Load bank configured to provide balanced loading on a per-phase basis.
 - b. Output Power:
 - 1) 0 percent
 - 2) 20 percent
 - 3) 30 percent
 - 4) 50 percent
 - 5) 75 percent
 - 6) 100 percent
 - c. Power Factor: 0.8
 - d. Output Voltage: 480 VAC $\pm$ 5 percent
 - e. Distortion: 5 percent maximum.
 - f. Output Frequency: 60 Hz $\pm$ 0.5 percent
 - g. Hold each output for 5 minutes.
 2. Phase Imbalanced Testing Parameters:
 - a. Load bank configured to provide 25 percent imbalanced loading on a per-phase basis.
 - b. Output Power:
 - 1) 0 percent
 - 2) 20 percent
 - 3) 30 percent
 - 4) 50 percent
 - 5) 75 percent
 - 6) 100 percent
 - c. Power factor: 0.8
 - d. Distortion: 5 percent maximum.
 - e. Output Frequency: 60 Hz $\pm$ 0.5 percent
 - f. Hold each output for 5 minutes.
 3. PCS Charge Performance Tests:
 - a. Testing Parameters:
 - b. Charge: 0 percent, 25 percent, 50 percent, 75 percent, 100 percent.
 - c. Distortion: 5 percent maximum.
 - d. Hold each charge capacity for 5 minutes.
- E. Alarm Circuits and Display Tests: Test alarm circuits, displays, test switches, and remote alarm contacts for proper function.
- F. Transient Step Response Test:
1. Perform the following load response tests:
 - a. 0 percent to 25 percent to 0 percent
 - b. 0 percent to 50 percent to 0 percent
 - c. 50 percent to 100 percent to 10 percent
 - d. 10 percent to 100 percent to 110 percent to 10 percent

2. Stable operating conditions re-established within 10 seconds following sudden change in load. At no point during the test shall the voltage or frequency fall outside of IEE 1547 limits. Hold each load step for 2 minutes. Record actual loads in KW, voltage (transient), frequency (transient), power factor, temperatures, as part of record.
- G. Sound Level Test:
 1. Audible sound pressure level of the BESS system equipment under full load.
 2. Record sound pressure at Octave Band Center Frequency (125 - 8000 Hz) at Octave Band Center Frequency (125 - 8000 Hz) at a distance of 5 feet around the equipment.
 3. Use an acceptable sound meter perform sound level measurements, record results.
- H. Test Data:
 1. Each test setup recorded on a drawing.
 2. Drawing detail indicating equipment tested, instruments used and location/connection points of those instruments.
 3. Tests plans and details stated above must be included as part of the package.
 4. Assemble test data in booklets and forwarded to the Owner If the tests show that certain requirements are not met, vendor to make necessary corrections to the equipment to satisfy design requirements before acceptance is made.
 5. Provide equipment required for the tests without additional cost to the owner.
- I. Manufacturer to provide documentation indicating outlined testing has been performed.

3.05 TRAINING

- A. Provide training for Owner's maintenance personal on procedures and related startup and shutdown, troubleshooting, servicing, and preventive maintenance.
- B. Review data in the operation and maintenance manuals with the Owner.

3.06 MANUFACTURER'S FIELD SERVICE

- A. Service Personnel:
 1. Nationwide service organization, consisting of factory-trained field service personnel dedicated to the start-up and maintenance of BESS and associated power equipment.
 2. Provide national dispatch center to coordinate field service personnel schedules. One toll-free number reaches qualified support person 24 hours/day, 7 days/week, 365 days/year. If emergency service is required, telephone response time 20 minutes or less and on-site response time four hours or less.
 3. Assign two local customer engineers to the site with a regional office as a backup.
- B. Replacement Parts Stocking:
 1. Available through an extensive network to ensure around-the-clock parts availability throughout the country.
 2. Full stock recommended spare parts by local field service personnel with back-up available from national parts center and the manufacturing location. The national parts center Customer Support Parts Coordinators on-call 24 hours a day, 7 days a week, 365 days a year for immediate parts availability. Ship parts from the national parts center within 4 hours on the next available flight out and delivered to the customer's site within 24 hours.
 3. Provide the following spare parts to owner:
 - a. Two complete sets of enclosure air filters.
 - b. One complete set of fuses (if used) for system.

3.07 MAINTENANCE CONTRACT

- A. Maintenance Contracts:
 1. Make available a complete offering of preventive and full-service maintenance contracts for both the BESS PCS and battery systems. Maintenance contract based on having local service technicians within a 4-hour time period.
 - a. Option 1: 2 Years total coverage - Parts, labor travel and batteries.

- b. Option 2: 5 Years total coverage - Parts, labor travel and batteries.
- c. Option 3: 10 Years total coverage - Parts, labor travel and batteries.
- d. Option 4: Same as option 3 with the addition of 100 percent battery coverage and complete battery replacement at year ten end.

END OF SECTION 26 33 63.16

**SECTION 26 37 13
MICROGRID ENERGY MANAGEMENT SYSTEM**

PART 1 GENERAL

1.01 SUMMARY

- A. This Section includes:
 - 1. Microgrid Energy Management System (MEMS)
 - 2. MEMS interactivity with Facility Building Automation System (BAS) for dynamic load reduction (load shedding).
 - 3. MEMS control of PV and BESS system(s)
 - 4. MEMS control of Generator system(s) (Future - Provided by Others)
- B. Design-build MEMS to satisfy the functional requirements for each required steady state operational mode and transitions between operational modes as specified in this Section.
- C. Provide labor, material, equipment, related services, documentation, and supervision required, including, but not limited to, manufacturing, fabrication, configuration and installation for the complete and functional integration of a MEMS as required for the complete performance of the Work, as shown on the Drawings and as specified in this Section.
- D. MEMS consists of all control, communications and data acquisition hardware and cabling as well as programmed or machine-learned control functions that enable the microgrid as a system the ability to manage on-site energy production resources and electrical utilization equipment to operate autonomously or grid connected, and seamlessly connect to and disconnect from the electrical utility grid. A MEMS manages the exchange of power, and provision of grid ancillary services across the point of interconnection (POI) with the electrical utility. Additionally, A MEMS assures continuity of electrical service to the facility electrical equipment connected on the customer side of the POI with the electrical utility.
- E. Contractor is responsible for the MEMS installation and will supplement system supplier's work to provide a complete and operable system. Coordinate equipment and systems provided by others that interface with MEMS to ensure necessary interconnections and compatibility are provided for required functionality of the MEMS.

1.02 REFERENCES AND RELATED PUBLICATIONS

- A. Referenced standards and publications listed below for a part of this specification to the extent referenced. The standards and publications are referred to in this Specification text by basic designation only.
 - 1. American National Standards Institute (ANSI)
 - a. ANSI C84.1 - Electric Power Systems And Equipment - Voltage Ratings (60 Hz)
 - 2. Underwriters Laboratories (UL):
 - a. System Equipment for Use with Distributed Energy Resources
 - 3. International Electrotechnical Commission (IEC)
 - a. IEC 60038 - Standard Voltages
 - b. IEC 61131-3 - Programmable Controllers, Part 3: Programming Languages
 - c. IEC 61850 - Communication networks and systems for power utility automation, Part 3: General requirements
 - d. IEC 62351 (SET) - Power systems management and associated information exchange - Data and communications security, Part 3: Communication network and system security
 - 4. Institute of Electrical and Electronics Engineers (IEEE):
 - a. IEEE C37.90 Standard for Relays and Relay Systems Associated with Electric Power Apparatus
 - b. IEEE 1115 Recommended Practice for Sizing Nickel-Cadmium Batteries for Stationary Applications
 - c. IEEE 1547-2018 Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces

- d. IEEE 1613 - Standard Environmental And Testing Requirements For Communications Networking Devices In Electric Power Substations
- e. IEEE 2030.7 - Standard for the Specification of Microgrid Controllers
- f. IEEE 2030.8 - Standard for the Testing of Microgrid Controllers
- 5. National Fire Protection Association
 - a. NFPA 70 - National Electrical Code (NEC)
 - 1) NEC 705, Part IV - Microgrid Systems
- 6. International Organization for Standardization (ISO)
 - a. ISO 9001 - Quality Management Systems – Requirements

1.03 DEFINITIONS

- A. ATS - Automatic Transfer Switch
- B. BAS - Building Automation System
- C. BESS - Battery Energy Storage System
- D. BMS - Battery Management System
- E. CTE - Cease to Energize
- F. DER(s) - Distributed Energy Resource(s)
- G. ESS - Energy Storage System
- H. EVSE - Electric Vehicle Service/Supply Equipment
- I. HIL - Hardware in the Loop
- J. IED - Intelligent Electronic Device
- K. HMI - Human Machine Interface
- L. HVAC - Heating, Ventilation and Air-Conditioning
- M. LAN - Local Area Network
- N. MEMS - Microgrid Energy Management System
- O. PC - Personal Computer
- P. PCC - Point of Common Coupling
- Q. PCS - Power Conversion System (BESS Inverter(s))
- R. PLC - Programmable Logic Controller
- S. PV - Photovoltaic System
- T. SCADA - Supervisory Control and Data Acquisition
- U. SoC - State of Charge (Specifically BESS State of Charge)
- V. TOU - Time of Use
- W. UPS - Uninterruptible Power Supply

1.04 SUBMITTALS

- A. MEMS Product Data:
 - 1. Detailed MEMS bill of materials
 - 2. MEMS equipment rack/cabinet elevations with dimensions and equipment callouts
- B. MEMS Design Documentation and Drawings
 - 1. MEMS sequence of operations in written narrative format
 - 2. MEMS sequence of operations in one of the following graphical formats:
 - a. Sequence matrix
 - b. Logic diagrams
 - c. Flow charts
 - 3. MEMS equipment location(s) on plans

4. MEMS control and communications cabling plan(s) and cable pull schedule(s)
 - a. MEMS vendor/integrator to issue as supplemental addendum to Design Drawings
5. Protection and control equipment one-line diagram
6. Protection and control equipment multi-line wiring diagram
7. Communication equipment one-line diagram
8. Communication equipment multi-line wiring diagram
9. Documentation of station service battery (24VDC) size calculation per IEEE 1115-2014.
10. Complete listing of holding registers available for 3rd party supervisory control and data acquisition of MEMS operation.
 - a. Holding register listing to provide data formats, units and any scaling factors if required.
 - b. Holding registers to be accessible via Modbus/TCP format or an alternate format if approved by EOR and Owner.
- C. Final Equipment Test Reports
- D. Equipment Pre-Functional Checklists for any Contractor furnished equipment or Systems.
- E. Commissioning Test Plans
- F. MEMS Digital Twin simulation environment for demonstration of system functionality to Facility Owner.
 1. MEMS Digital Twin simulation demonstration of complete MEMS functionality to be provided to Facility Owner prior to MEMS system Commissioning.
- G. Operation and Maintenance (O&M) Data and Documentation
 1. MEMS operator manual detailing system operational behavior and procedures for local HMI based control of the MEMS.
 2. MEMS required maintenance procedures and testing intervals..
 3. MEMS administrative login usernames and passwords.

1.05 MEMS CONTRACTOR DESIGN

- A. Contract drawings and this section indicate the general nature and functional requirements of the MEMS, and do not show extent of potential components required for functional operation of system. Drawings are intended to aid the contractor and/or subcontractor and/or supplier in designing and providing complete and operational MEMS compliant with Code and utility requirements.
 1. Raceways, cable routing, and wiring for MEMS field devices shown on the drawings are provided for Contractor information and to represent specific design requirements required for successful deployment associated with basis of design equipment.
- B. Provide additional design documentation and drawings required to integrate the MEMS equipment, accompanying power, controls and communications cabling into the facility and to ensure interoperability with on-site energy production, storage, switching, relaying and overcurrent protective resources.
- C. Produce comprehensive sequence of operations matrix or logic diagram(s) that details all inputs and monitored system statuses to the MEMS controller required to generate the managed transitions between each Documented microgrid steady state operational mode. Outputs of the sequence of operations matrix or logic diagram(s):
 1. State transitions (Tx).
 2. Steady state operation (SSx) numbers.

1.06 COORDINATION

- A. Coordinate features of electrical distribution equipment, power monitoring and control components to form an integrated system of interconnected and compatible components.
- B. MEMS integrates and programmed to control and/or monitor the following Facility equipment and/or systems:
 1. Switchboards

- a. Pertaining to the controls integration of electrically operable circuit breakers.
2. Electricity Metering
3. PV System
4. BESS
5. Engine Generator
 - a. The fixed diesel generator(s) may not operate in parallel with the electrical utility.
 - b. Engine generator is Not In Contract - Equipment to be provided separately by facility owner.

1.07 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
 1. Manufacturer/vendor regularly engaged in the manufacture, development and installation of the data acquisition, electric power monitoring, protection systems and/or microgrid systems for a period of at least five (5) years and can demonstrate that these products have been utilized in satisfactory use in functioning systems for similar applications. Demonstrate more than five (5) years, capability in data acquisition, control system design, modeling, installation, and start-up.
 2. Current ISO 9001 certification and applicable quality assurance system that is regularly reviewed and audited by a third-party registrar. Manufacturing, inspection, and testing procedures developed and controlled under the guidelines of the quality assurance system.
 3. Manufacturer/vendor service, repair, and technical support services available 24 hours 7 days a week basis.
- B. Installer Qualifications: Installer firm with a minimum of five (5) years of successful installation experience with projects utilizing equipment similar in type and scope required for this Project.
 1. Authorized representative of the MEMS equipment manufacturer for both installation and maintenance of units required for this Project.
- C. Startup Personnel Qualifications: Specially trained personnel who are either directly employed by the MEMS equipment manufacturer or certified by the MEMS equipment manufacturer to perform MEMS commissioning and startup.
- D. Work performed and materials used in accordance with the National Electrical Code and applicable local regulations and ordinances. Process controllers, assemblies, materials, and equipment listed and labeled by Underwriter's Laboratories or by nationally recognized testing agency acceptable to authorities having jurisdiction and marked for intended use.
- E. MEMS components to be built tested and labeled in accordance with applicable NEMA, ANSI and UL standards and installed to meet local regulations and ordinances.
 1. Contractor and MEMS Manufacturer to furnish components, devices, and accessories listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for indicated use and installation conditions.
- F. MEMS system design to comply with applicable federal and state regulations and local codes in effect on the date of the Contract for the federal, state, locality, or other jurisdiction in which the System is to be installed and operated.
- G. If any MEMS equipment and components are normally manufactured to standards that are not acceptable in the jurisdiction in which the system will be installed, conformance, certification and listing of the equipment to authority having jurisdiction standards and requirements is to be performed by the Contractor utilizing AHJ authorized listing and labeling services.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Prior to delivery to the Project site, ensure suitable storage space is available to store materials in a well-ventilated area protected from weather, moisture, soiling, extreme temperatures, humidity, and corrosive atmospheres. Protect materials during delivery and storage in compliance with manufacturer stated storage requirements. As a minimum, store indoors in clean, dry space with uniform temperature to prevent condensation. In addition, protect electronics from all forms of electrical and magnetic energy that could reasonably cause damage.
- B. Deliver materials to the Project site in supplier's or manufacturer's original wrappings and containers, labeled with supplier's or manufacturer's name, material or product brand name, and equipment tag number or service name as identified within the Contract Documents.
- C. Inspect and report any concealed damage or violation of delivery storage, and handling requirements to the Engineer.

1.09 WARRANTY

- A. Warrant MEMS hardware against defects in manufacture for a period of five (5) years
- B. Provide warranty of MEMS system operation following date of substantial completion for a period equaling two (2) full years of operation.
- C. Provide warranty for the installation and workmanship following date of substantial completion for a period equaling one (1) full year.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. ELM Microgrids

2.02 MICROGRID ENERGY MANAGEMENT SYSTEM (MEMS)

- A. General:
 - 1. List equipment or equipment assemblies by Underwriters' Laboratories and bear a UL label.
 - 2. MEMS equipment and equipment assemblies has a short circuit current rating (SCCR) greater than the maximum available fault current (SCCA) expected at the point of delivery to equipment.
 - 3. Refer to Drawings for maximum allowable equipment footprint.
 - 4. Designed and commissioned by the MEMS Design-Build contractor.
 - 5. Satisfy the Project functional requirements for each required steady state operational mode and transitions between operational modes as defined within the Design documentation.
 - 6. Designed to be functionally compliant with requirements of IEEE 2030.7 to allow future modifications to the operational capabilities of the MEMS.
 - 7. Designed and installed to permit functional modification of hardware and software by the facility owner or a representative of the facility owner without incurring any additional licensing, service, administrative or other fees from the MEMS design build-contractor or any equipment manufacturers associated with the MEMS hardware installed under this project's scope of work.
- B. MEMS Equipment Enclosures:
 - 1. Install MEMS equipment within ventilated enclosures with lockable access doors and designed and constructed to permit replacement of individual MEMS components without disassembly or removal of adjacent MEMS components.
 - 2. Provision MEMS enclosures with integral equipment receptacles or power distribution units as needed to supply power to enclosed equipment.
 - 3. Microgrid Design-Build contractor to determine if active ventilation or cooling is required for each cabinet and provide ventilation fans or active cooling equipment as necessary to avoid heat-soaking of enclosed equipment.

4. Where exposed to weather, provide NEMA Type 3R enclosure with integral HVAC equipment to ensure MEMS equipment operates within manufacturer recommended temperature and humidity conditions. Power for HVAC to be supplied from a separate optional standby distribution circuit.
- C. MEMS Station Service Control Power
 1. MEMS Control Power Voltage: 24VDC
 2. Station Service power to ensure continuous operation of MEMS control and communication equipment and all essential switching devices for a duration no less than thirty (30) minutes.
 - a. MEMS control power to be continuous regardless of microgrid steady state operational mode or transition sequence.
 3. Station Service battery to be Nickel-Cadmium and sized per IEEE 1115-2014.
 4. Station Service battery, battery charger and DC distribution equipment to be integral to MEMS control enclosure.
 5. If MEMS components requires uninterruptible 120V power, provide uninterruptible power supply (UPS) as integral equipment to MEMS control cabinet.
 6. Coordinate with MEMS vendor to determine requirements for MEMS power supply connections.
- D. Wiring/Terminations:
 1. Small wiring, necessary fuse blocks and terminal blocks within the MEMS equipment racks, cabinets and enclosures furnished as required. Control, communications, metering and/or datalogging components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., suitably marked for identification corresponding to appropriate designations on manufacturer's wiring diagrams and MEMS equipment rack and cabinet elevations.
- E. Marking and Labeling
 1. Engraved nameplates, mounted on the face of the primary MEMS control enclosure(s) and all auxiliary MEMS control enclosures as indicated on the drawings.
 2. See Section 26 05 53 - Identification for Electrical Systems for additional requirements.
- F. Control/Monitoring Equipment and Cabling:
 1. MEMS control equipment and control cabling designed and provisioned by the MEMS design-build contractor with sufficient discrete and analog input/output and communications protocols to be interoperable with all devices or systems to be controlled and monitored as required to satisfy the intent of the Design.
- G. Communications Equipment and Cabling:
 1. MEMS inclusive of communications equipment and cabling designed and provisioned by MEMS design-build contractor as required to satisfy the intent of Design.
 2. Dedicated MEMS Ethernet LAN independent of facility Ethernet and provisioned with cyber-secure hardware and software to detect and prevent unauthored network traffic and access.
- H. Human Machine Interface (HMI):
 1. Provide single local HMI, located within main electrical room for the purposes of recalling MEMS system status and local operator control of MEMS.
 - a. Local HMI display monitor accepts touch inputs for operator commands and status recall.
 - b. Local HMI provisioned with a keyboard and mouse for operator convenience. Keyboard and mouse integrated into a retractable or folding shelf system. Height of keyboard and mouse shelf 42 inches above finished floor when deployed for use.
 - c. MEMS operational status available via local HMI with an access level that does not require a password.
 - d. MEMS operational control available via local HMI with an access level that requires a username and password.

- e. MEMS operational control restricted to a whitelist of facility owner approved personnel.
- 2. Provide a web-based interface for the MEMS HMI to provide remote access to HMI access and control functions.
 - a. MEMS design-build contractor identifies desired functionality for web-based HMI with facility owner.
 - b. MEMS operational status available via remote web-based HMI.
 - c. MEMS operational control available via remote web-based HMI with an access level that requires a username and password.
 - d. MEMS operational control restricted to a user whitelist of facility owner approved personnel.
- 3. Provide a web-based kiosk mode HMI interface to provide remote display of MEMS operational status.
 - a. MEMS design-build contractor identifies desired functionality for web-based kiosk mode HMI with facility owner.
- I. MEMS E-Stop
 - 1. Provide physical and digital emergency stop (E-Stop) push buttons wired to the MEMS controller and integrated into MEMS HMI touchscreen.
 - 2. E-Stop Physical Button(s)
 - a. Mushroom button type push to trip with clockwise turn to reset.
 - b. Red color with white text/labeling "Emergency Power Off".
 - c. Clear impact resistant guard cover to prevent inadvertent operation and with hinged action to permit access to mushroom button.
 - d. Location as indicated on Design Drawings
 - 3. E-Stop Virtual Button(s)
 - a. Integrated into MEMS HMI operational display.

2.03 MEMS FUNCTIONAL SEQUENCE OF OPERATIONS

- A. Overview
 - 1. Integrate and program MEMS to control and/or monitor equipment previously listed in this Section as required to implement steady state operational modes and state transitions
 - 2. Provide real-time direct control over the on-site power generation and energy storage resources. See Design Drawings for DER nameplate ratings.
- B. Operational Setpoints
 - 1. PCC Maximum Export: 100 kW
 - 2. PCC Minimum Import: N/A
 - 3. PCC Maximum Import: N/A
 - 4. BESS Max SoC: 95% (Operator adjustable 50-100 percent)
 - 5. Load Shed Disable SoC: 50% (Operator adjustable 25-75 percent)
 - 6. Load Shed Enable SoC: 15% (Operator adjustable 15-50 percent)
 - 7. BESS Min Startup SoC: 15% (Operator adjustable 0-50 percent)
 - 8. Utility Grid Stability Timer: 5 seconds (Operator adjustable 1-300 seconds)
 - 9. Microgrid Start Delay Timer: 10 seconds (Operator adjustable 1-300 seconds)
- C. Steady State Operational Modes (SSx)
 - 1. Grid Connected Mode (SS1)
 - a. Utility grid power is available
 - 1) DER(s) permitted to enter grid following (CSI) mode of operation when both grid frequency and voltage are within acceptable range of IEEE 1547-2018 Table 4.
 - 2) Loss of microgrid system control when utility power is available not to result in intentional state transition from SS1.
 - b. MEMS performs the following functions
 - 1) Serve as the dispatch agent for the BESS and PV systems

- 2) Optimize BESS charge and discharge cycle timing to minimize facility electrical operating costs.
 - 3) Ensure BESS charging is concurrent with daily PV energy production. BESS to be charged exclusively with PV energy.
 - 4) Employ a learning algorithm to continually optimize BESS dispatch based on PV facility demand and PV power generation patterns and seasonal utility TOU rate schedules.
 - c. MEMS will manage PV power operational setpoints as required to satisfy electrical utility net metering and interconnection requirements.
 - 1) Net export limitations for this facility are expected, MEMS system to be provisioned with control functions and user definable setpoints to enable net export management at the Facility PCC.
 - (a) Manage power flow across PCC per requirements of 2.03.B.
 - (b) SEL-751 (MID) to supervise reverse power flow across PCC and trip controllable circuit breaker 52-BESS for power flow in excess of PCC Maximum Export control setpoint for greater than (3) seconds.
 - 2) Provision MEMS for asset-backed demand response operation should the Facility Owner opt-in to an electrical utility demand response program.
 - (a) Receptive of Utility real and reactive power signal.
 - (b) Receptive of Utility power dispatch duration signal.
 - (c) Receptive of any signal found in current version of SunSpec Common Smart Inverter Profile (CSIP) and as required for DER asset interconnection by the Electrical Utility.
 - (d) Utility signal to be via any of the following protocols
 - (1) Modbus/TCP
 - (2) DNP3
 - (3) IEEE 2030.5
 - (4) OpenADR
 - (5) JSON
 - d. Controllable Circuit Breaker State
 - 1) Closed: 52-MID, 52-MDP
 - 2) Open: 52-GEN
 - 3) Variable: 52-BESS
 - e. SS1 Exit Transitions
 - 1) Mode SS1 is the default (preferred) operational mode for the MEMS. The microgrid system will continue to operate in SS1 until any of following transpires:
 - (a) MEMS E-Stop Condition - See state transition T3
 - (b) Unexpected electrical utility power outage - See state transition T1.
 - (c) Manual operator command to Island Mode (SS2) with BESS SoC above BESS SoC Minimum setpoint. - See state transition T6.
2. Island Mode (SS2)
 - a. Utility grid power is unavailable.
 - 1) PCS operates in isochronous mode and serves as swing bus for real and reactive power to maintain microgrid bus voltage and frequency.
 - 2) Verify desired voltage and frequency range limits with Project Engineer.
 - b. MEMS performs the following functions:
 - 1) With PCS supporting the islanded facility load for a minimum of 5 minutes, the MEMS to permit PV and GEN system operation concurrently with the PCS to support the Facility resilient load.
 - 2) MEMS HMI to display current BESS state of charge
 - 3) MEMS HMI to display estimated time remaining in SS2 mode operation based on 1 minute average of Facility resilient load demand, PV power production and PCS discharge power.

- 4) It is acceptable for time remaining estimate to display "N/A" if 1 minute average of PCS power indicates BESS is in charge mode (PV system power greater than Facility resilient load demand).
- 5) Manage breaker 52-GEN as required to synchronize generator to facility electrical system.
- 6) Manage breaker 52-MDP as required to restore BESS SoC using exclusively photovoltaic energy
 - (a) Open 52-MDP breaker at BESS SoC equal or below Load Shed Enable SoC setpoint
 - (b) Close 52-MDP breaker at BESS SoC above Load Shed Disable SoC setpoint
 - (c) 52-MDP breaker open action may only be performed under the following conditions:
 - (1) Operating in Mode SS2
 - (2) Generator reporting critical low fuel condition (no remaining fuel)
 - (3) Photovoltaic power production available (daylight hours).
- c. Controllable Circuit Breaker State
 - 1) Closed: 52-BESS
 - 2) Open: 52-MID
 - 3) Variable: 52-MDP, 52-GEN
- d. SS2 Exit Transitions
 - 1) The microgrid system will continue to operate in SS2 until any of the following transpires:
 - (a) Utility grid is restored. See state transition T2.
 - (b) MEMS E-Stop is activated. See state transition T3.
 - (c) MEMS failure to maintain local electrical power system island. See state transition T4.
 - (d) BESS SoC is below the BESS SoC Minimum setpoint. See state transition T4.
3. Island Black (SS3)
 - a. Utility grid power is unavailable and all Local Electrical Power System AC distribution buses are de-energized.
 - b. Island black mode is an undesirable temporary power system condition. Sustained operation in Island Black mode should be avoided whenever possible
 - c. Island Black mode is not intended for system maintenance. Breaker lock-out/tag-out procedures for maintenance still apply.
 - d. Controllable Circuit Breaker State
 - 1) Closed: 52-MID
 - 2) Open: 52-GEN
 - 3) Remaining in last state: 52-MDP, 52-BESS
 - e. SS3 Exit Transitions
 - 1) The MEMS will exit mode SS3 as quickly as possible in the following transition priority order:
 - (a) MEMS E-Stop conditions are present. See state transition T3.
 - (b) Utility grid is available. See state transition T2.
 - (c) BESS State of Charge (SoC) is above BESS Min Startup SoC setpoint. See state transition T5.
 - (d) BESS State of Charge is below the BESS SoC Minimum setpoint - No exit possible until Utility grid is available. See also state transition T2.
4. MEMS Stop Mode (SS4)
 - a. Operation of any physical or virtual E-Stop button shall result in the MEMS control system initiating an immediate cessation of MEMS command and control operation.
 - 1) Opening of all controllable DER feeder circuit breakers.

- 2) All MEMS controlled DERs placed in CTE state in accordance with IEEE 1547-2018, Section 4.5.
 - b. Within this mode, the MEMS HMI controls and all command and control operation shall remain locked-out.
 - c. MEMS Stop Mode shall not preclude supply of Utility power to the facility electrical power system.
 - 1) A live bus condition at the Microgrid switchboard/switchgear may be present in MEMS Stop mode if utility grid is active or has been restored.
 - 2) Facility loads may be served in MEMS Stop mode if utility grid is active or is restored.
 - d. MEMS to report E-Stop alarms on HMI to facilitate system troubleshooting and restoration.
 - e. MEMS E-Stop mode is not intended for system maintenance. Breaker lock-out/tag-out procedures for maintenance still apply.
 - f. Controllable Circuit Breaker State
 - 1) Closed: N/A
 - 2) Open: 52-GEN
 - 3) Remaining in last state: 52-MID, 52-MDP
 - g. SS4 Exit Conditions
 - 1) The microgrid system will continue to operate in SS4 until all tripped physical E-Stop buttons are reset and the E-Stop alarm is manually cleared at the HMI. See state transition T7.
- D. State Transitions (Tx)
 1. Loss of Utility Grid (T1)
 - a. Automated transition from SS1 to SS3 upon unexpected loss of Utility grid power.
 - b. Occurring when operating in mode SS1 and MEMS detects Utility grid instability.
 - c. T1 Sequence of Operations:
 - 1) MEMS to continuously monitor Utility grid voltage and frequency conditions.
 - 2) MEMS to initiate sequence T1 if Utility grid conditions satisfy any of the following:
 - (a) Voltage and Frequency equal to zero.
 - (b) Voltage outside of IEEE-1547-2018 Table 12 limits and for corresponding durations.
 - (c) Frequency outside of IEEE-1547-2018 Table 18 limits and for corresponding durations.
 - 3) Execute the following operations in successive order:
 - (a) Command PCS to CTE state
 - (b) Command PV inverter(s) to CTE state.
 - (c) Verify Microgrid switchgear/switchboard dead bus condition
 - (d) Annunciate alarms on HMI for Loss Of Utility.
 - 4) Controllable Circuit Breaker Operations:
 - (a) Open: N/A
 - (b) Close: N/A
 - (c) No Action: ALL
 2. Utility Grid Resynchronization (T2)
 - a. Automated transition from SS2 to SS1 upon Utility grid power restoration
 - b. Occuring when operating in modes SS2 and MEMS detects Utility grid restoration and persistent stability.
 - c. T2 Sequence of Operations:
 - 1) MEMS to continuously monitor Utility grid voltage and frequency conditions.
 - 2) MEMS to initiate Utility Grid Stability Timer countdown if Utility grid conditions satisfy all of the following:

- (a) Voltage within IEEE-1547-2018 Table 12 limits and for corresponding durations.
 - (b) Frequency within of IEEE-1547-2018 Table 18 limits and for corresponding durations.
 - 3) Any voltage or frequency deviations outside of IEEE-1547 ranges stated above will restart Utility Grid Stability Timer countdown and associated grid stability monitoring process.
 - (a) Display Grid Stability Timer countdown on HMI.
 - 4) Following Utility Grid Stability Timer has expiration, execute following operations in successive order:
 - (a) Synchronize PCS voltage and frequency to Utility Grid
 - (b) Modify PCS setpoints to achieve zero real and reactive power flow across PCC
 - (c) MID supervisory relay to close MID breaker upon detection of net zero power flow across PCC and synchronization between Utility grid and microgrid island.
 - (d) Concurrent with MID breaker close operation, command PCS to CTE state.
 - (e) Restart PCS in grid following (CSI) mode according to current economic and demand response dispatch priorities.
 - 5) Controllable Circuit Breaker Operations:
 - (a) Open: 52-GEN
 - (b) Close: 52-MID
 - (c) No Action: 52-BESS, 52-MDP
- 3. MEMS Stop (T3)
 - a. Automated transition from SS1, SS2 or SS3 to SS4
 - b. Occurring in response to operation of a physical MEMS E-Stop button, HMI based MEMS emergency stop button activation, or MEMS loss of communication or control power.
 - c. MEMS loss of power or communication and/or MEMS E-Stop is intended to interrupt operation of all on-site microgrid controlled power generation resources.
 - d. MEMS loss of power or communication and/or MEMS E-Stop is not intended to interrupt supply of normal Utility grid power.
 - e. Annunciate alarms on HMI to facilitate system troubleshooting and restoration.
 - f. T3 Sequence of Operations:
 - 1) MEMS to continuously monitor station service power. Loss of station service is an E-Stop event.
 - 2) MEMS to continuously monitor MEMS communications networks and DER asset heartbeat signals. Loss of communications is an E-Stop event.
 - 3) MEMS to continuously monitor MEMS E-Stop physical and digital buttons. E-Stop button activation is an E-Stop event.
 - 4) Upon a MEMS E-Stop event condition, execute the following:
 - (a) Command PCS to CTE state.
 - (b) Command PV inverter(s) to CTE state.
 - (c) Annunciate alarms on HMI for MEMS E-Stop condition.
 - 5) Controllable Circuit Breaker Operations:
 - (a) Open: 52-GEN
 - (b) Close: N/A
 - (c) No Action: 52-MID, 52-MDP, 52-BESS
- 4. Loss of Microgrid Island (T4)
 - a. Automated transition from SS2 to SS3
 - b. Occuring when operating in mode SS2 and MEMS fails to maintain microgrid voltage and frequency stability and minimum BESS SoC.
 - c. T4 Sequence of Operations:

- 1) MEMS to continuously monitor microgrid island voltage and frequency conditions.
 - 2) MEMS to continuously monitor BESS SoC.
 - 3) MEMS to initiate sequence T4 if microgrid island conditions satisfy any of the following:
 - (a) Voltage outside of IEEE-1547-2018 Table 12 limits and for corresponding durations.
 - (b) Frequency outside of IEEE-1547-2018 Table 18 limits and for corresponding durations.
 - (c) BESS SoC is below BESS Min SoC setpoint
 - 4) Execute the following operations in successive order:
 - (a) Command PCS to CTE state.
 - (b) Command PV inverter(s) to CTE state.
 - (c) Verify Microgrid switchgear/switchboard dead bus condition.
 - (d) Close MID circuit breaker.
 - (e) Annunciate alarms on HMI for Loss of Microgrid Island condition.
 - 5) Controllable Circuit Breaker Operations:
 - (a) Open: 52-GEN
 - (b) Close: 52-MID
 - (c) No Action: 52-MDP, 52-BESS
5. Island Start (T5)
- a. Automated transition from SS3 to SS2.
 - b. Occurring when operating in mode SS3 and MEMS detects sustained dead bus condition on Microgrid switchgear/switchboard bus.
 - c. T5 Sequence of Operations
 - 1) MEMS to continuously monitor Microgrid switchgear/switchboard for voltage and frequency.
 - 2) MEMS to initiate Microgrid Start Delay Timer countdown only if Microgrid conditions satisfy all of the following:
 - (a) Microgrid switchgear/switchboard bus has RMS voltage equal or near zero.
 - (b) BESS SoC is greater than BESS Min Startup SoC setpoint.
 - 3) Conditions outside of ranges stated above will restart Microgrid Start Delay Timer countdown and associated monitoring process.
 - (a) Display Microgrid Start Delay Timer countdown on HMI.
 - 4) When Microgrid Start Delay Timer has expired, execute the following operations in successive order:
 - (a) MEMS to open MID breaker
 - (b) MEMS to command the PCS into grid forming (VSI) mode of operation to accept the Facility resilient load.
 - (c) PCS to start using pre-programmed voltage slew rate to minimize inrush current associated with Facility resilient load acceptance. Slew rate to be set as high as possible without overloading PCS.
 - (d) PCS to operate in isochronous mode and serves as swing/slack bus for real and reactive power to maintain microgrid bus voltage and frequency.
 - 5) The maximum number of attempts for transition T5 to be five (5). If T5 sequence fails to establish a microgrid island after the maximum permissible number of attempts, execute following remedial action operations in successive order:
 - (a) Command PCS to CTE state.
 - (b) Command PV inverter(s) to CTE state.
 - (c) Annunciate alarms on HMI for Island Start Failure.
 - (d) Remain in Mode SS3.
 - (1) Wait for Operator manual commands
 - (2) Wait for Grid Restoration conditions associated with Transition T8.

- 6) Controllable Circuit Breaker Operations:
 - (a) Open: 52-MID (T5 successful)
 - (b) Close: 52-MID (T5 unsuccessful)
 - (c) No Action: N/A
6. Transfer to Island (T6)
 - a. Automated transition from SS1 to SS2.
 - b. Occurring when operating in mode SS1 and MEMS operator inputs a manual request for closed transition transfer to mode SS2.
 - c. T6 Sequence of Operations
 - 1) MEMS to continuously monitor Utility grid for voltage and frequency.
 - 2) MEMS to continuously monitor Microgrid switchgear/switchboard for voltage and frequency.
 - 3) MEMS to permit transition T5 only if Microgrid conditions satisfy all of the following:
 - (a) Utility Grid has been previously stable for a duration longer than Utility Grid Stability Timer.
 - (b) Microgrid switchgear/switchboard has live bus condition.
 - (c) BESS SoC is greater than BESS Min Startup SoC setpoint.
 - 4) Execute the following operations in successive order:
 - (a) Command PV inverter(s) to CTE state.
 - (b) Command PCS to start in grid following (CSI) mode.
 - (c) Modify PCS setpoints to achieve zero real and reactive power flow across PCC.
 - (d) MID supervisory relay to open MID breaker upon detection of net zero power flow across PCC.
 - (e) Concurrent with MID breaker open operation, command PCS to grid forming (VSI) operating mode.
 - (f) Permit restart of PV inverter(s).
 - 5) Controllable Circuit Breaker Operations:
 - (a) Open: 52-MID
 - (b) Close: 52-BESS (if previously in Open state)
 - (c) No Action: 52-MDP, 52-GEN
7. MEMS Stop Recovery (T7)
 - a. MEMS operational mode transition from SS4 to SS3.
 - b. Occurring in response to MEMS detection of a successful clearing of MEMS stop command via physical and/or digital EPO buttons reset and verification of MEMS power and communication health.
 - c. A live bus condition at the Microgrid switchboard/switchgear bus may be present during this transition.
 - d. T7 Sequence of Operations
 - 1) Execute the following operations in successive order:
 - (a) MEMS HMI controls and all command and control operations to be restored.
 - (b) De-assert E-Stop alarms on HMI.
 - 2) Controllable Circuit Breaker Operations:
 - (a) Open: N/A
 - (b) Closed: N/A
 - (c) No Action: ALL
8. Grid Restoration (T8)
 - a. Automated transition from SS3 to SS1 upon Utility grid power restoration.
 - b. Occuring when operating in modes SS3 and MEMS detects presence of Utility grid with persistent stability.
 - c. T3 Sequence of Operations:

- 1) MEMS to continuously monitor Utility grid voltage and frequency conditions.
- 2) MEMS to initiate Utility Grid Stability Timer countdown if Utility grid conditions satisfy all of the following:
 - (a) Voltage within IEEE-1547-2018 Table 12 limits and for corresponding durations.
 - (b) Frequency within of IEEE-1547-2018 Table 18 limits and for corresponding durations.
- 3) Any voltage or frequency deviations outside of IEEE-1547 ranges stated above will restart Utility Grid Stability Timer countdown and associated grid stability monitoring process.
 - (a) Display Grid Stability Timer countdown on HMI.
- 4) Following Utility Grid Stability Timer expiration, execute the following conditional operations:
 - (a) If MID breaker is closed and Microgrid switchgear/switchboard bus have voltage and frequency equal to Utility grid voltage and frequency, then take no further
 - (b) If MID breaker is open and Microgrid switchgear/switchboard bus has RMS voltage equal or near zero, then close MID breaker.
- 5) Controllable Circuit Breaker Operations:
 - (a) Open: N/A
 - (b) Close: 52-MID (if MID open at T8 initiation)
 - (c) No Action: 52-MID (If MID closed at T8 initiation).

PART 3 EXECUTION

3.01 MEMS EQUIPMENT INSTALLATION

- A. General:
 1. MEMS design-build contractor is responsible for MEMS control and communications equipment as well as microgrid balance of system components.
 2. MEMS design-build contractor responsible for control and communications cabling interface with MEMS to assure proper termination at MEMS equipment and at the remote end equipment to be controlled or monitored.
 3. Provide seismic anchoring/restraints of cabinets raceway and equipment, refer to Section 260529, Hangers and Supports for Electrical Systems and Section 26 05 48 - Vibration and Seismic Controls for Electrical Systems.

3.02 MEMS TESTING

- A. Provide the service of a competent, factory-trained engineer or authorized by manufacturer of MEMS equipment to technically supervise and participate during programming, final connections, adjustments and tests for system.
- B. When system is complete and prior to the substantial completion, furnish testing equipment and perform following tests:
 1. Before energizing system, check for correct wiring connections and test for short circuits, ground faults, continuity, and insulation.
 2. Test each MEMS controlled or monitored device or system for proper operation and auxiliary function with respect to MEMS operation.
 3. Operation of the MEMS in each steady state operational mode and transition function.
 - a. Coordinate and agreed upon MEMS testing dates and times with the Facility Owner in advance.
 4. Submit a printout of the entire test procedure to engineer with letter of certification for completed and operational MEMS.
 5. When defects in the work are detected, make repairs, and repeat the tests as required.

3.03 MEMS WARRANTY SERVICE AND MONITORING

- A. Warrant MEMS equipment and functional operation of microgrid system against defects in manufacturing, assembly, installation, and programming for a period of two years following substantial completion.
- B. Provide continuous remote monitoring of MEMS. Provide quarterly reports of MEMS status and controlled operations to the Facility Owner for a period of two years following substantial completion.
- C. Quarterly checks consist of reviewing the operation of the MEMS system with Owner's operating and maintenance personnel, providing additional hands-on instruction, and assisting in execution of programming revisions.

3.04 MEMS TRAINING

- A. Provide operation and maintenance training for Owner's personnel.
- B. Conduct a minimum of two scheduled maintenance training sessions upon completion of work. MEMS operation and maintenance training sessions shall include the following:
 - 1. Walk-thru of the installed and operational MEMS equipment identifying function and maintenance requirements for each component.
 - 2. Conduct training session covering MEMS status recall and operation.
 - 3. Training sessions with fully qualified, trained representative, of equipment manufacturer who is thoroughly knowledgeable of specific installation.
 - 4. System operation and administration from local HMI as well as from the web-based HMI.
 - 5. Review of MEMS O&M binder materials.
 - 6. Supervised control of MEMS operation by authorized Facility Owner personnel. Test operation shall place the MEMS in each steady state operational mode following a predetermined and written test procedure. Test procedure shall begin and end with MEMS in steady state operational mode SS1 as defined by the Design.
- C. Provide a minimum of one refresher training session at the request of the Facility Owner or Facility Owner maintenance personnel within the initial warranty period.

END OF SECTION 26 37 13