Portland General Electric

All Source RFP Technical Specifications – Energy Storage Projects

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APPENDIX M – ENERGY STORAGE PROJECTS

TECHNICAL SPECIFICATIONS

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

REQUEST FOR PROPOSAL

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Appendix M4

Attachment 01

Exhibit 01

ENERGY STORAGE TECHNICAL DOCUMENTS

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

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REQUEST FOR PROPOSAL

NO.	DATE	REVISION	BY	CHK'D	APPROVALS	
1	26Oct21	Issued for Implementation	1898 & Co.	SC & KW	JAL	Jared Lathrop
2	3Dec21	Rev 2 – correction to 3.2.4 & 3.2.5, replacement of section 3.2.9	Colin Solini	Kevin Whitener	JAL	Jared Lathrop
3	14Apr23	Update from 2021 Version	1898 & Co.	PGE	CPA	Craig Armstrong
4	15Dec23	Rev 4, see redline changes	Kevin Whitener	Craig Armstrong	CPA	Craig Armstrong

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Acronyms and Abbreviations

AC	Alternating Current
ACI	American Concrete Institute
AHJ	Authority Having Jurisdiction
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BIL	Basic Insulation Level
°C	degrees Celsius
CAD	Computer-aided design
CT	Current Transformer
DART	Days away, restricted or transferred
DC	Direct Current
EMI	Electromagnetic Interference
EMR	Experience Modification Rate
ESS	Energy Storage System
E-Stop	Emergency Stop
ESIC	Energy Storage Integration Council
FAT	Factory Acceptance Testing
HMI	Human Machine Interface
HV	High Voltage
HVAC	Heating, Ventilation, and Air Conditioning
IEEE	Institute of Electrical and Electronic Engineers
IFC	Issued for Construction
LV	Low Voltage
MV	Medium Voltage
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NETA	InterNational Electrical Testing Association
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Administration
PCS	Power Conversion System
PDF	Portable Document Format
PF	Power Factor
POI	Point of Interconnection
psi	pounds per square inch
PT	Potential Transformer
QA/QC	Quality Assurance/Quality Control
QC	Quality Control
RPA	Reference Point of Applicability
RTU	Remote Terminal Unit
SAT	Site Acceptance Test
SCADA	Supervisory Control and Data Acquisition
SEC	Site Energy Controller
SOC	State of Charge or Energy: Nominal Energy Remaining / Nominal Full Pack Energy Available
Specification	Project Technical Specification
TRIR	Total Recordable Incident Rate
UL	Underwriters Laboratories
UPS	Uninterruptible Power Supply
VPN	Virtual Private Network

0.0 SCOPE

This Project Technical Specification (Specification), including Appendices, comprise or constitute requirements to design, fabricate, ship, assemble, test, startup, commission, warrant and make ready for service a fully functional energy storage system complete with accessories as required by the Agreement. This Specification defines specific engineering, operating and performance requirements for the Project that is intended for installation on the Owner's electric system. The Project is to be designed to be in a restricted access setting and configured to meet applicable standards required of other Owner equipment with respect to safety, operations, maintenance and environmental impact.

1.0 CONFORMANCE TO SPECIFICATION

1.1 Applicable Documents

Except as modified herein, the Project, including the energy storage technology, power conversion system (PCS), and site energy controller (SEC) or plant controller shall be designed, manufactured, and tested in compliance with the latest versions (including any issued revisions) of the applicable standards of American National Standards Institute (ANSI), Institute of Electrical and Electronic Engineers (IEEE), National Electrical Code (NEC), National Electrical Manufacturers Association (NEMA), Occupational Safety and Health Administration (OSHA), American Society for Testing and Materials (ASTM), American Society of Mechanical Engineers (ASME), National Fire Protection Association (NFPA), and Owner safety practices. See Appendix A for applicable standards and codes.

1.2 Communications

- Communications systems at the DER interface must comply with IEEE 1815-2012 for DNP3 communications and DNP3 Users Group Application Notes AN2018-001 DNP3 Profile for Communications with DERs
- The Customer must be able to directly communicate with each protective relay within the project. This connection will be through an Ethernet port on the relay specifically reserved for this purpose. The customer communicates to these relays using Acselerator Team software. This interface can be alternatively be through a relay serial port with the proper converter.

1.3 Cybersecurity

When the Contractor has provided the 30% submittal for the Project network and controls architecture, Customer and Contractor will collaborate to design the Project cybersecurity design.

1.4 Data

The Customer's primary method of operations and maintenance monitoring of the project is through the Customer's command center. It is acceptable for the Contractor to provide a user interface of their own design, but the Customer will not use that interface for day-to-day operations. For this reason, it is important for the project plant controller to provide data to the Customer to adequately serve this purpose. The Customer will develop graphics, status, command and alarm graphics for their command center and the Contractor will provide data in sufficient detail to facilitate this. This includes data down to the rack level of the DC system, DC contactor positions, cell temperatures (min, max and average within the rack), rack SOC and voltage, and any alarms associated with the rack.

Contractor will provide a draft data tag list at the time of 30% review of the network and controls architecture submittal.

1.5 Direct Buried Underground Cable

Direct buried underground cable is not allowed at all within the project scope. This includes the BESS yard, the collector substation and any ancillary power or communications connections. This includes power cables, control and communications cables. The only exception is for bare earthing conductors. All other cables including non-metallic (such as fiber optic cable) must be protected with underground conduit.

1.6 Customer System Operating Voltages

For purposes of this specification, the Customer's system voltages have been provided as nominal voltages. This is not necessarily the same as the Customer's operating voltages. This can be a critical distinction for design and procurement of Project transformers and for performing electrical studies. It is the Contractor's responsibility to verify with Customer the actual operating voltages of the various interconnections.

1.7 Protective Relay Settings

For all protective relays within the scope of the project, the Contractor will provide the proposed settings and relay logic for review and approval by the Customer.

1.8 Safety

- The Project must be compliant with all applicable provisions of IEEE 1547-2018 or IEEE 2800 depending upon interconnection voltage, Underwriters Laboratories (UL) 1642, UL 1741 Supplement B, UL 1973, UL 9540, UL 9540A and NFPA Codes including NFPA 855. The Project must be able to protect itself from internal failures and utility grid disturbances. As such, the Project must be self-protecting for alternating current (AC) or direct current (DC) component system failures. In addition, the Project must be able to protect itself from various types of external faults and other abnormal operating conditions on the grid.
- The Project must be designed in compliance with and ultimately meet all applicable federal, state, and local safety standards and regulations regarding construction and potential exposure to chemicals and regarding container or enclosure resistance to hazards such as ruptures and exposure to fire. Prepackaged and pre-engineered energy storage systems shall be UL 9540 listed per large scale fire testing performed at the cell, module, unit, or system level until it passes the criteria specified in UL 9540A. Contractor shall provide documentation of UL 9540A test results with the proposal.

- All Project systems and equipment must be grounded in accordance with the NEC and adhere to the guidelines in IEEE 80 and IEEE 142.
- For all Project equipment, Contractor shall provide information and training to first responders on all known or reasonably foreseeable safety issues related to the equipment, including appropriate responses on how to handle the Project in case of an emergency, such as fires, off-gassing or module ruptures.
- The Project must be designed to minimize the risk of injury to the workforce and public during installation, maintenance, and operation.
- Visual and audible fire alarms and fire alarm panel trouble alarms shall be included as necessary per all applicable fire and safety codes. If a fire alarm panel is existing at a site, the Project fire alarm panel will be required to tie into that site panel and therefore must be compatible. Otherwise, if the fire alarm panel is standalone, it must provide its own means for dial-up. Cellular signal strength must be confirmed by Contractor if that is the chosen solution.
- A physical Emergency Stop (E-Stop) button is required to be installed at all entrances and exits of the buildings or containers. The E-Stop button shall have the ability to open contactors/breakers to the inverter and batteries isolating the DC and AC potential, without affecting the fire protection, monitoring and other safety measures required by the applicable safety standards and regulations. This E-Stop design must be such that no damage is caused to the PCS or any other systems.
- The Contractor must submit a copy of its Company Safety Plan and a comprehensive site-specific safety plan (at least 30 days prior to the start of the Work) that the Contractor and all Subcontractors will understand and follow during execution of the Work. The site-specific safety plan shall incorporate, at a minimum, plans and policies that are at least as stringent as federal, state, and Owner safety regulations and policies. (i.e. include reference to Contractor Safety Program and all Owner Safety Plans/Policies).
- Designated safety personnel during construction of the Project shall have a minimum of five years of safety experience or an equivalent level of skill through a training certification or professional degree. Resumes will be provided to support this requirement.
- Contractor and all Subcontractors must submit historical safety data for review prior to start of the Work: previous three years of safety stats: Total Recordable Incident Rate (TRIR); Days Away, Restricted or Transferred (DART); Experience Modification Rate (EMR) on official letterhead; and OSHA inspection history and any OSHA citation history. Contractor shall use the following benchmarks for TRIR (less than or equal to 2.0, DART less than or equal to 1.0, EMR less than 1.0) and membership with ISN. Inspections and citations should be evaluated on a case-by-case basis. If TRIR, DART, EMR are outside of recommended benchmarks, a risk mitigation plan is required.
- At minimum, Contractor's Site-Specific Safety Plan shall include provisions with respect to:
  - Daily job planning
  - Activity Hazards Analysis
  - Analysis of Utility locations (proper mark-out for underground facilities)
  - Incident reporting procedures
  - Project safety statistics tracking and reporting

  - Personal Protective Equipment
  - Emergency Plans to include evacuations and inclement weather
  - Fire Management (i.e. Fire Safety)
  - Excavation plans
  - Sanitation (hand wash/temporary toilets)
  - Demolition activities (if applicable)
  - Procedures for a Regulatory Visit (should one occur)
  - Deficient Project Safety Performance (recovery plan)
  - Site Safety Orientation requirements
  - Security of work zones, material yards, etc.
  - Behavioral Based Safety Plan
  - HAZCOMM
  - OSHA

1.9 Environmental Requirements

- Contractor and its Subcontractors and vendors engaged in the performance of the Work shall comply with all Applicable Laws.
- Spill Prevention Control and Counter Measure Plan - Proper site containment when equipment has equal to or greater than 1,320 gallons of liquid.
  - Containment shall include Petro pipe and a lockable drain valve.
  - All containment basins shall include grating as required to access and maintain equipment located in the containment area.
- The Project shall be designed for proper operation without de-rating for the following conditions and limits:
  - Ambient temperature range as defined in Section 4.3.9.
  - Zero gas emissions during normal operating conditions.
  - Noise produced by any Project operation shall comply with the requirements set forth in Section 4.3.10 herein.
  - The Project must be designed to minimize risk of harm to the environment including land contamination or disturbance (footprint), water contamination or diversion, and air emissions, as required by permitting and best Industry Standards.
  - Contractor must provide sufficient information specific to their product and the Project to facilitate utility personnel training and communications with emergency response and environmental agencies. Safety Data Sheets shall be provided, as applicable.

1.10 Seismic

- The structural and nonstructural components of all buildings, Control Shelters/Rooms, free standing structures, structural equipment supports, and all associated foundations and anchorages shall be designed and constructed to withstand the effects of earthquake motions and seismic loading in accordance with the requirements of the most recent versions of the Oregon Structural Specialty Code and ASCE 7 (respectively) with supplements No. 1 and 2 with the following parameters:
  - Risk Category IV
  - Seismic Design Category D
  - Site Soil Class D, unless otherwise determined by the Geotechnical Engineer
  - Ip is 1.5
- All electrical equipment shall be designed to the 'High Seismic Qualification Level' in accordance with IEEE 693 Standard.
- For all anchors embedded into concrete that resist seismic loading, the cracked concrete provisions of American Concrete Institute (ACI) 318-11, Appendix D must be considered.
- Anchor design must be governed by ductile yielding of a steel element (anchor or attachment), unless the exceptions of ACI 318-11, Appendix D are met.
- Post-installed anchors installed into hardened concrete must be an International Building Code Compliant Anchor for Seismic Design Category D and shall be designed and installed in accordance with the cracked concrete provisions.

1.11 Specification Interpretation

- If the Contractor is in doubt as to the meaning of any part of this Specification, or if Contractor finds discrepancies in or omissions in this Specification, the Contractor must submit a request for a written interpretation or correction of the Specification. Any request for a written interpretation shall be made to the Owner Representative.
- Any interpretation or correction of the Specification will be given in writing by the Owner Representative.

2.0 GENERAL REQUIREMENTS

2.1 Workmanship

All Work must be done and completed in a thorough, workmanlike manner by personnel skilled in their various trades, notwithstanding any omission from drawings or this Specification. All parts of the Work shall be constructed accurately to standard gauge so that renewals and repairs may be made when necessary, with the least possible expense.

2.2 Design and Material

All materials used in the Project shall be new and of the specified quality. All components and workmanship must be free from physical and electrical flaws and imperfections. The design shall not only be effective in engineering characteristics, but it must also comply with the finish requirements stated herein.

2.3 Document Submittals

The Contractor shall provide all documents and deliverables as set forth in M1-01-02 (Engineering Documents Drawings and Other Deliverables) and M1-01-02-01 (Documents and Deliverables Table). This shall include, but not be limited to, the example documents listed below. In addition, the Contractor shall provide a completed ESIC Energy Storage Technical Specification Template V3.0 at the time of proposal. This template is available from the Electric Power Research Institute.

The preliminary drawings submitted (30% review) shall be accompanied by design memoranda which shall provide, when applicable, all data, calculations, and information necessary for an engineering review and understanding of the proposed design. The 30% review level is defined as drawings and documents that define the design concept. Examples of documents to be submitted at the 30% level include but are not limited to:

- Site Plan Layout
- AC Single-line Drawing(s)
- DC Single–line Drawing(s)
- Grounding Plan
- PCS Layout and Details
- Energy Storage Layout and Details
- Architectural Drawings
- Foundation Plan
- Heating, Ventilation, and Air Conditioning (HVAC) Drawings and Details
- Fire System Drawings and Details
- Grading and Drainage Plan
- Storm Water Pollution Prevention Plan
- Equipment Specification List
- Control System and Network Architecture Diagrams
- Preliminary Data Tag List
- Communication System Block Diagrams with Proposed Communications Protocols and Communications Media
- Access Road Plan, Cross Sections, and Details
- Site Fencing Drawing
- Electrical Load Flow, Arc-Flash and Short-Circuit Calculations
- Purchase Specs or Data Sheets for Long Lead Items

- Equipment Seismic Qualification Reports
- Enclosure/Building Structural Calculations

The Owner shall have the right to require the Contractor to make design alterations for conformance to the design requirements of the Statement of Work without additional costs to the Owner. The review of such alterations shall not be construed to mean that the drawings have been checked in detail, shall not be accepted as justification for an extension of time, and shall not relieve the Contractor from the responsibility for the correctness of the drawings and compliance to the Statement of Work. The Contractor shall make, at his own expense, any revisions needed to correct the drawings for any errors or omissions which may be found by the Owner.

The Contractor shall submit for review multiple packages of final drawings ready for construction (90% review). Calculations and drawings shall be submitted together. After review, the Contractor shall stamp the final drawings “Issued for Construction”, or IFC, to indicate that these drawings will be the official drawings used for construction activities. Drawings submitted at 90% review shall include, but are not limited to:

- Site Plan Layout
- AC Single-line Drawing
- AC Three-Line Drawings
- DC Single–line Drawing
- DC Three-Line
- Uninterruptible Power Supply (UPS) drawings for black start / islanding systems (if applicable)
- Drawings Grounding Plan and Details
- PCS Layout and Details
- Energy storage Layout and Details
- Building/Enclosure Drawings and Details:
    - Structural
    - Architectural
    - Plumbing
    - Mechanical
    - Electrical
    - Fire Detection
    - Fire Suppression, if required.
    - Gas Detection, Ventilation & explosion mitigation if required
- Grading and Drainage Plan and Details
- Foundation Drawings, Plans and Details

- Raceway Plan and Details
- Storm Water Pollution Prevention Plan, if required
- Equipment and Materials List / Bill of Materials listing major Equipment and Materials
- Control System Diagrams / Logic Diagrams
- Communication System Block Diagrams
- Access Road Plan, Cross Sections, and Details
- Site Fencing Drawing
- Electrical Load Flow, Arc-Flash and Short-Circuit Calculations
    - Arc-Flash Labels
- Control Input/Output List
- Supervisory Control and Data Acquisition (SCADA) Points List
- Purchase Specs or Data Sheets for All Equipment
- Site Logistics
- Location and content of Labels and Signage
- Section 2.6 Study Reports
- Communication Network Documents
- Communication Network Block Diagrams
- Equipment Seismic Qualification Reports
- Structural Calculations
- Commissioning and Testing Documents
- Operations and Maintenance Documents
- A Separately Packaged and Distinct First responder Training Program

A final set of signed “IFC” drawings for each sub-system shall be available on-site before construction of that sub-system may proceed. To the extent required by Applicable Laws, and/or the Authority Having Jurisdiction (AHJ) over Project permits, construction issue drawings shall be signed and stamped by an Oregon registered professional engineer involved in the Project. Electronic registered professional engineer stamps shall be provided for electronic issues.

- The following information shall be shown on each drawing submitted:
    - Contractor’s name.
    - Owner contract and release number.
    - Owner equipment number if indicated in the Agreement or Contractor’s equipment number if not indicated in the Agreement.
    - Description of drawings (Title).
    - Latest revision and date.

- Construction submittals shall be reviewed by Contractors' registered engineer or architect (as applicable) and, to the extent required by Applicable Laws, and/or the AHJ over Project permits, shall bear review stamp from Contractor's registered engineer or architect (as applicable), or the registered engineer/architect's designee, where appropriate. Documentation provided by equipment manufacturers shall not require additional stamp by a registered engineer if those equipment manufacturer documents are included in a 30%, 90% or IFC submittal package. These reviewed submittals shall be submitted to the Owner at a minimum for the following items:
  - As-built drawing markups delivered after completion of Work.
  - Drilled pier construction work plan (if applicable).
  - Backfilling materials.
  - Structural concrete mix design and associated material certifications.
  - Complete reinforcing bar fabrication, details, and bar setting drawings.
  - Anchor bolts.
  - Structural steel shop fabrication drawings.
  - CMU block including certification of compliance with appropriate design ASTM standards.
  - Welding procedure specifications, qualifications, and QC plan.
  - Disposal site for exported soil material.
  - Masonry mortar mix.
  - Grout mix and procedures.
  - Roof deck erection drawings.
  - Completed manufacturer application for roof guarantee along with shop drawings of the roofs showing all dimensions, penetrations and details. The roof guarantee shall contain all technical information including: Deck types, roof slopes, base sheet and/or insulation assemblies (with method of attachment and fastener type) and manufacturers membrane assembly proposed for installation. The roof guarantee should contain accurate and complete information including: Proper names, addresses, zip codes, and telephone numbers.
  - Roof membrane guarantee, 20-year labor and materials membrane / system guarantee.
  - Roofing material submittals, product data information and material certifications.
  - Layout and attachment of insulation indicating fastener and adhesive patterns per the manufacturer's installation requirements to meet Factory Mutual Global tested wind uplift resistance.
  - Certification from roof manufacturer that board insulation materials are acceptable with roof membrane and included in roof manufacturer 20-year system guarantee.
  - Copy of manufacturer's warranty and installers warranty for control shelter.
  - Doors, frames and hardware.
  - Louvers

  - Paints
  - Sealant
  - Cable cut sheets and testing results.
  - Transformer testing results.
  - Inverter testing results.
  - Conductors and grounding rods.
  - Exothermic welds and grounding connections.
  - Conduit, tray, and conduit fittings.
  - Mandrel
- All drawing / document reviews shall comply with the process set forth in M1-01-02 (Engineering Documents Drawings and Other Deliverables).

2.4 Record Drawings

The Contractor shall maintain a record drawing set on-site always with clear markings on the drawings indicating it as the record set. The record set shall be available for Owner review always during performance of the Work. The Contractor shall furnish record drawings to reflect any changes including red line drawings made during or after installation and commissioning of the Project. One set of marked-up paper print drawings all with a new revision number shall be forwarded within six weeks from the Substantial Completion Date. A transmittal letter shall accompany the mailing itemizing the revised drawings.

2.5 Project Specific – Operations and Maintenance Manual

No later than six weeks from the Substantial Completion Date, the Contractor shall furnish two complete identical set of detailed Operation and Maintenance Manuals in both print and digital (i.e. PDF) formats for the Project. These manuals shall be accompanied by a letter of transmittal and shall have a table of contents, contain all illustrations, assembly drawings, outline drawings, wiring diagrams, replacement parts list that includes part number identification, a list of recommended spare parts, and instructions necessary for storing, installing, operating and maintaining the Project. The illustrated parts shall be numbered for identification. Additionally, these books shall contain instructions and test procedures for integrating the Project into Owner control and monitoring computer networks. All information contained therein shall apply specifically to the Equipment and Materials furnished and shall not include instructions that are not applicable. All illustrations shall be incorporated within the print of the page to and drawings bound into the book form a durable and permanent reference book. Binding holes of all Table of Contents pages, illustrations shall be reinforced with nylon circlets to prevent this information from being torn out of the book.

The Owner will inform the Contractor six weeks after receipt of the Operation and Maintenance Manuals either that there are “No Comments”, “Furnish as Corrected” or “Correction Required”. If there are “No Comments”, the Contractor shall promptly furnish two additional sets identical to the submitted copy. If there are corrections needed, one set will be returned to the Contractor by the Owner. The corrections shall be promptly incorporated in the Operation and Maintenance

Manuals and a total of four complete, identical sets of such revised Operation and Maintenance Manuals shall be furnished to the Owner in both print and digital formats.

One additional, identical Operation and Maintenance Manual shall be kept in control shelter.

2.6 Study Reports and Calculations

The Contractor shall submit all design study, calculations, dynamic modeling simulation, shake table testing, and field test reports to the Owner in a timely manner. All reports and calculations shall be signed by an Oregon registered professional engineer and shall list assumptions, study methods, results, significant findings and conclusions.

The Contractor shall prepare the following study reports and calculations as specified below:

- Seismic and Wind Loading Calculations: The Contractor shall provide seismic and wind loading calculations for all buildings, structures, nonstructural components, equipment and structural supports, and all associated foundations and anchorages as specified in Section 1.4.
- Seismic Qualification Report: Contractor shall prepare a report demonstrating the Project's compliance with the seismic standards specified in Section 1.4 for the following:
    - Battery racks IEEE-693-2005-Annex J
    - Batteries – IEEE 693-Annex J
    - Switchgear-IEEE 693-Annex M
    - Step-Up Transformer-IEEE 693-Annex D
    - Inverters (including rack mount)-IEEE 693- Annex L
    - Medium Voltage (MV)/High Voltage (HV) Breaker, IEEE 693- Annex C
    - MV/HV Disconnect Switch IEEE 693-Annex E
    - MV/HV Termination and Support Structure, IEEE 693-Annex N
    - Pad-mount Isolation Transformers (Anchorage Only), IEEE 693-Annex D
    - Electronic Devices, Panels, Switchboards, solid-state rectifiers-IEEE 693 Annex L
- Structural Calculations: The Contractor shall provide structural calculations for all structural supports and foundations, the building enclosing the batteries, and shelters, Control Shelters/Rooms, and equipment foundations and all nonstructural components in accordance with Oregon Structural Specialty Code requirements as specified in Section 1.4 of this document.
- Grounding System Study: The Contractor shall perform soil resistivity measurements and studies as necessary to determine the parameters for the Project's grounding system. Grounding studies shall identify step and touch potentials, as applicable, for each facility where new equipment is added as part of the Project scope. The Project grounding system shall be designed to function independently of the adjacent grounding system. The grounding system for the Project may be connected to the ground grid for the adjoining substation at the discretion of the Owner at Contractor's cost. If connected to the adjoining grounding system, the contractor shall perform a study to verify that step and touch potential

are within tolerable limits. Connections to and routing of ground cables to connect the ground grid of the adjoining grounding system shall be provided by the Contractor. Grounding for all multi-component outdoor structures shall include two (2) or more independent ground connections. The Project grounding system shall also be designed in such a way as to reduce electromagnetic interference (EMI) coupled to the grounding system from power electronic converters, such as through single-point grounding systems. Designs and study shall adhere to IEEE 80, IEEE 81, IEEE 142, and the Project's geotechnical engineering report where applicable.

- Electrical Studies: The Contractor shall provide electrical studies as required to determine control response and settings, including load flow, short-circuit, cable ampacity, arc-flash analysis, protection coordination and voltage drop using industry-standard engineering software agreed-upon by the Owner. For the purposes of the system electrical studies, the Contractor shall provide inputs data for an accurate power flow and dynamic simulation model of the Project compatible with the Owner's CYME database and software. Contractor shall perform dynamic simulations, utilizing CYME. Alternatives to CYME will not be allowed.
- Relay and Control Settings: The Contractor shall provide complete documentation of all protective relay and Project control settings for the Project's batteries, inverters, control systems, and AC systems up to the POI. Such documentation shall include a protection and control criteria document (separate protection and control criteria documents are acceptable), all calculations and time current coordination curves used in the development of the settings.
- Depending upon the scope of the Project, additional studies such as transformer sizing, DCS/UPS sizing, harmonics and auxiliary power studies may be required. Refer to M1-04-01 for specific requirements of these studies.

2.7 Testing and Test Reports

- For those tests described in IEEE 1547.1 under Clause 5 – Type Testing, Contractor shall provide certifications from Nationally Recognized Testing Laboratory (NRTL) for the results of those type tests. NRTL must be registered and authorized in the United States as well as in the country where type testing is performed. Any required type tests lacking documentation from a NRTL must be performed as a part of on-site commissioning and witnessed by the customer.
- The Contractor shall, within 30 days prior to any on-site testing, submit a "Master Test Plan and Procedures" document indicating the order in which the tests will be conducted, and the test method being used along with required instrumentation for Owner approval.
- The Contractor shall furnish, at the Contractor's own expense, necessary facilities, personnel and test equipment for the required tests.
- The Contractor shall notify the Owner not less than two weeks in advance of the day when:
  - Manufacture, fabrication and integration starts for the batteries, inverters, controls and transformers of each major deployment.
  - The batteries, inverters, controls, transformers and other major components allocated for each major deployment are ready for testing and inspection prior to packaging for shipment.

- Should the Owner elect to waive the right of inspection or of witnessing tests and accept certified test reports instead, the Owner will notify Contractor no later than three business days ahead of the scheduled inspection or test.
- Witnessed factory tests shall be made in the presence of Owner personnel or authorized representative. The test procedures shall be subject to review and acceptance by the Owner prior to arrival at testing location, provided that non-acceptance of any part of the procedures is consistent with the Statement of Work. The Contractor shall bear all costs of such testing except for the compensation and expenses of Owner personnel. If scheduling such tests to accommodate the Owner causes schedule delays, then said delays will be accommodated on a day-by-day basis to the extent they negatively impact the critical path.
- One copy of the certified reports of all tests shall be furnished to the Owner in digital and print formats for review. The Owner will inform the Contractor within two weeks after the receipt of the certified test reports either that there are no exceptions noted or that the test results show noncompliance with the Specification. Contractor shall provide the test data for a representative sample of each of the major components.

2.8 Factory Acceptance Testing Requirements

The Contractor shall be responsible for compliance with all standard factory test procedures that check the quality and performance of the Equipment and Materials.

The Contractor shall perform those tests specified below and in other sections of this Specification. The Contractor shall propose additional tests to be conducted if required. Where appropriate, tests should conform to those contained in ANSI, NEMA, ASME, NEC, ASTM, NETA, IEEE and UL standards and guidelines. Where standards are not suitable or applicable, other common industry procedures and mutually acceptable methods shall be used.

If certain tests are performed by firms other than the Contractor, the Contractor shall furnish the test reports and certify that the necessary testing has been performed.

2.8.1 Factory Acceptance Testing of the Battery/Cells

The Contractor shall test and submit test data for the cells designated for use on this Project. At a minimum, the following tests shall be performed:

- Amp hour capacity
- UL 1642 Certificates (if applicable)
- As applicable, maximum noxious and toxic material release rates for same cell design but not necessarily a specific production lot.

The Contractor shall propose a test plan for all required cell tests. Required tests may be proposed as a percentage of the cells in production lots. Test data for production lots other than those being supplied for this Project are not acceptable.

2.8.2 Factory Acceptance Testing of the PCS and Control System

The Contractor shall develop and submit for Owner approval a Factory Acceptance Test (FAT) Plan. The FAT Plan shall be in general accordance with Appendix C of this Specification. The Contractor shall work cooperatively with the Owner to develop a formal FAT Plan based on the appendix.

At a minimum, tests shall be conducted to demonstrate that all controls, protective functions and instrumentation perform as designed and adhere to this Specification. Successful tests performed on a scaled-down version of the overall scope of supply will be deemed to meet the intent of this Section provided that Owner approves the design of the system under test. The PCS FAT testing must be performed using a subset of the exact make and model of the batteries being supplied for the project. Testing does not necessarily have to be performed at the PCS manufacturer’s facilities. It can be performed at some location with the means to perform grid-connected and integrated testing. The tests shall demonstrate that the PCS is capable of synchronizing with and operating in conjunction with the utility connection. A report along with applicable graphs of each test and relevant data file(s) including a power quality report will be provided by the Contractor to the Owner upon completion of the FAT. This file should be captured at a minimum of 512 samples per cycle resolution.

Witness test shall demonstrate the following, at a minimum:

- Run at rated power for duration of specified system capabilities
- Normal and failure mode operating sequence and protective functions
- Verification of accuracy of measured input/output voltage and currents
- Verification of response to basic P and Q commands
- Verification of dynamic power factor (PF) control via SCADA system (e.g., Communications Protocol)
- Verification of power curtailment via SCADA system (e.g., Communications Protocol)
- Verification of islanding and black start capabilities
- Verification of power quality and compliance with IEEE power quality requirements through the use of power quality metering equipment with historization and harmonic analysis

2.9 Site Acceptance Test

The Site Acceptance Test shall be in accordance with Appendix F of this Specification, to be provided at a later date by Contractor as an exhibit to the Agreement. Owner will assist Contractor during the Site Acceptance Test process. In addition, the Contractor shall demonstrate that all aspects of the System integrate and coordinate as intended. At a minimum, the Contractor shall demonstrate that all control and management systems, including but not limited to, all levels of energy storage management system, PCS controls, overall site controls, and protective features operate as intended. Other balance-of-plant systems shall be tested in conjunction with the overall system tests (e.g. HVAC, fire alarm, thermal runaway mitigation system operational alarms, etc., lighting, security).

2.9.1 Actual Operating Experience

It may not be possible due to system constraints to test all facets of the Project function as part of the performance verification tests specified above. The actual operating experience of the Project through Final Completion shall be deemed an extension of the performance verification tests.

Actual operating experience will be documented through Owner-furnished sequence of event recorders, oscillographs, digital fault recorders and other system monitoring equipment capable of identifying system disturbances and associated Project performance. Additional information may be provided by monitoring equipment installed by the Owner at other locations. Operation may also be documented with the Contractor-furnished power quality meters, as determined by the Owner.

2.9.2 Other Compliance Tests

The Contractor is responsible for obtaining both before (or with all equipment de-energized) and after Project installation, measurements to ensure the Project complies with this Specification in the following areas. The Owner reserves the right to perform (or request others to perform), at Owner expense, identical compliance test measurements for the following:

- Broadband frequency signal strength and noise voltage.
- Harmonic voltages and currents adhering to IEEE 519, 1547 and 2800. The proper IEC Class A meter must be used for this testing and a power quality report must be provided showing harmonic content in TRD (not THD) for each harmonic and interharmonic up to the 50th order. Harmonic content must be measured at each of four different PCS operating levels.
- Audible noise measurements adhering to AHJ requirements.

2.10 Spare Parts

The Project specific Operations and Maintenance Manual provided by Contractor shall list the required spare parts to be furnished with the Project by Contractor. Each spare part shall be interchangeable with and shall be made of the same material and workmanship as the corresponding part included with the product furnished under these Specifications. Enclosed storage space for spare parts required on site shall be provided by Contractor. If climate-controlled space is required, additional space shall be included in the Control Shelter or energy storage system enclosure(s).

2.11 Special Tools

The Contractor shall furnish a complete set of any special tools, lifting devices, templates and jigs, which are specifically necessary for installation and/or maintenance of the Project. Any accessories normally furnished with this system required for satisfactory operation of the Project, and not specified herein, shall also be furnished by the Contractor. All tools furnished shall be new and plainly marked for identification. One complete set of tools shall be furnished for the Site.

2.12 Cleaning and Painting

All waterproof enclosures shall be thoroughly cleaned of rust, welding scale, and grease, and shall be treated to affect a bond between the metal and paint which shall prevent the formation of rust under the paint. A priming coat shall be applied immediately after the bonding treatment. The final finish shall consist of two coats of paint of specified color and type. Contractor shall submit painting specifications and procedures for Owner approval.

Waterproofing is the combination of materials or systems that prevent water intrusion into structural elements of the buildings or its finished spaces.

2.13 Shipping Requirements

- The Contractor shall prepare Equipment and Materials for shipment in such a manner as to protect from damage in transit. Each item, box or bundle shall be plainly and individually identifiable for content according to item number, Owner contract number, Contractor's identifying number, and complete shipping address. The Contractor shall pay attention to the proper packaging and bracing of the apparatus to assure its safe arrival.
- Systems, equipment, materials and components shall be transportable from the designates port at normal speeds over North American highways and railways and meet all United States Department of Transportation hazardous materials and other requirements. System components may be shipped separately as needed and assembled on-site. Battery shipments shall adhere to the requirements of Title 49 Code of Federal Regulations (CFR) Part 173.185.
- Energy storage media shipping containers will each be provided with shipping shock sensors of the appropriate G-rate sensitivity prior to loading at the manufacturer's dock.
- Energy storage media shipping containers will each be provided with shipping tilt sensors prior to loading at the manufacturer's dock.
- Shipping of storage media shall be via air-ride van or trailer.
- A complete itemized bill of lading, which clearly identifies and inventories each assembly, subassembly, carton, package, envelope, etc., shall be furnished and enclosed with each item or items at the time of shipment.

2.14 Installation

The Contractor shall be responsible for quality of construction to meet best Industry Standards and design requirements. Equipment shall be installed in accordance with their listing and the manufacturer's instructions.

2.14.1 Civil/Structural

The permanent Project shelters and required foundations, structures, anchoring (including the building or enclosure that will house the batteries), and other civil/structural work shall be designed by and under the supervision of a qualified registered professional engineer and registered architect, in each case in the state where the Project is located. All such work shall be in accordance with seismic design requirements as specified in Section 1.4 of this Specification and M1-02-01 (General Civil Requirements).

2.14.2 Geotechnical Testing

The Contractor shall perform geotechnical investigations and geotechnical report shall be in accordance with the requirements set forth in M1-02-01 (General Civil Requirements), including all information necessary to complete civil/structural and grounding design. Contractor to determine cable thermal ampacity based on geotechnical investigations.

2.14.3 Site Development

The Contractor shall perform all necessary studies and calculations for hydrology and drainage, erosion control, landscaping, NPDES (Stormwater Pollution Prevention Plan) and site grading to comply with local agency regulations. The Contractor shall be responsible for all surveys (e.g. topographic, Dig Alert, potholing) required to attain an accurate design.

Drainage structures and piping within the Project boundaries shall be grounded if constructed of materials capable of conducting electricity.

2.14.4 Excavation

The Contractor shall perform all excavation necessary for installation of all foundations and utilities. All excavation shall be in accordance with OSHA regulations and the geotechnical report performed or to be performed by Contractor. Excavation spoils shall be the Contractor's responsibility and may be used for backfill or embankment if suitable for this application as directed by the project geotechnical report/ engineer. Unsuitable or excess excavated material shall be disposed of properly. The Contractor shall verify that earth material exposed in excavations is consistent with those assumed for the Contractor's foundation designs.

2.14.5 Construction Surveying

The Contractor shall furnish all labor, equipment, material and services to perform all surveying and staking required for the completion of the Project in conformance with Contractor's design and the Statement of Work. Survey information shall be included in Project as-builts.

The Contractor shall retain qualified survey crews knowledgeable in proper and up-to-date survey techniques and shall use these qualified survey crews when conducting the survey. Such crews shall be under the supervision of a professional land surveyor licensed in the state where the Project is located.

2.14.6 Fills

Earth fill material adjacent to and below structures shall conform to the design requirements for the structure and the geotechnical report performed or to be performed by Contractor. Contractor-prepared specifications and drawings shall indicate the types of soil to use for fills and compaction requirements.

Fill shall be placed as uniformly as possible on all sides of structural units. Fill placed against green concrete or retaining walls shall be placed in a manner which will prevent damage to the structures and will allow the structures to assume the loads from the fill gradually and uniformly.

2.14.7 Fencing

Site perimeter fencing is required for the Project. Such fencing shall comply with the Owner fence standards as described in M1-01-07.

2.14.8 Lighting and Convenience Outlets

Lighting shall be provided for all indoor and outdoor areas of the project. The lighting system shall provide personnel with illumination for operation under normal conditions and means of egress under emergency conditions. Luminaries shall be LED type, mounted so they are easily accessible for maintenance and lamp replacement, to the maximum extent practical; for both interior and exterior. Emergency lighting shall be powered from self-contained batteries, with chargers, within a self-contained emergency lighting unit.

The power supply for the lighting system shall generally be from low voltage (LV) lighting panelboards. The emergency egress lighting shall consist of self-contained battery lanterns. Outdoor lighting shall be limited to providing fixtures mounted on building, container, or light standards. Light fixtures shall be Dark Sky compliant to help preserve the night sky from light pollution.

The lighting levels shall be designed in accordance with the Illuminating Engineering Society to provide proper illumination levels recommended. Minimum level in the energy storage system area shall be 30-foot candles (323 lux) at 30 inches (762 millimeters) above plane, when occupied, and adequate levels for illumination for video and security equipment when unoccupied; 3.0-foot candles (22 lux) at 30 inches (762 millimeters). Minimum level in the control room and maintenance area shall be 50-foot candles (538 lux) at 30 inches (762 millimeters) above floor plane.

Follow state and local lighting energy efficiency standards, as applicable. Electric power to light fixtures shall be switched with motion sensors in energy storage system rooms. When unoccupied, sensors shall reduce levels to minimum for security. Motion sensors with built-in override function shall be provided in areas where the light can be completely turned off, such as storerooms, switchgear rooms, and maintenance area. Wall mounted switches and sensors shall be provided at the latch side of the door entrance.

Electric power to outdoor light fixtures shall be switched with motion or heat detectors to keep lights off when not required. Convenience outlets and switches throughout shall be industrial grade rated for standard voltages and amperes per country standards. Convenience outlets located outdoors shall be provided with weatherproof snap-action covers. Outlets shall be spaced in the energy storage area such that there is a maximum 100 feet (30 meters) distance to a receptacle outlet, unless codes allow or require otherwise. As a minimum, an accessible receptacle outlet shall be reachable within 25 feet (7.6 meters) from each HVAC unit. Provide outdoor receptacles protected by ground fault interrupters, and interior receptacles in locations as required by codes. In finished areas, general-purpose power outlets shall be located on each wall and in no case shall they be located more than 10 linear feet (3.0 meters) apart.

2.14.9 Control Shelter (if control room not provided in building-based solution)

For container-based solutions, the Contractor shall design, engineer, and provide a shelter suitable for use to house the Project controls and all indoor components common to the Site. The shelter shall be designed to comply with the Oregon building code requirements. The Contractor shall provide the shelter required to accommodate the Project controls commensurate with the Project design life, including but not limited to seismic events, wind loads or other controlling criteria. The shelter shall be considered an occupied space and shall be designed in accordance with codes pertaining to occupied space.

If energy storage media is located within containers, the design shall be such that normal maintenance and operation can be performed without personnel entering the enclosure.

The Project shelter and containers shall be designed with the appropriate insulation to meet local building codes and ensure an energy efficient operation of the HVAC and/or ventilation system. Control shelter will be installed on a graded concrete pad and all components mounted thereon shall be designed for and anchored sufficiently for transportation to the jobsite. Control shelter shall be designed without shipping splits. The control shelter shall be made from either steel (galvanneal), aluminum or stainless steel. The control shelter shall have doors to accommodate installation and replacement of equipment housed in the structure. The roof shall have a pitch design with a minimum slope of 0.25 inch per linear foot and shall be designed to support interior or exterior loads of 100 pounds per linear foot without compromising the roof load design.

The control shelter shall be equipped with DC cabinet, AC panels and disconnects (480/240/120), lights, switches, receptacles, controls rack, fire suppression, HVAC units, push buttons, HVAC controls, cable tray, wireway, grounding system and conduit.

Exit and fire door hardware shall conform to UL specifications. Installation of exits shall conform to NFPA No. 80.

2.14.10 Project Building (if applicable to proposed system)

The Contractor shall design, engineer, and provide a building suitable for use to house all indoor components of the Project. The building shall be designed to comply with the Oregon State Building Code requirements. The Contractor shall provide the building required to accommodate the Project commensurate with the Project design life, including but not limited to seismic events, wind loads, or other controlling criteria as specified in Section 1.4.

The building shall be designed with the appropriate insulation to meet local building codes and ensure an energy efficient operation of the HVAC and/or ventilation system. Exit and fire door hardware shall conform to UL specifications. Installation of exits shall conform to NFPA No. 80.

2.14.11 Structural Steel and Connections

All structural steel shall comply to the following applicable materials standards:

- Wide Flange Shapes - ASTM A992

- Angles and Channels - ASTM A36
- Plates - ASTM A572 Grade 50
- High Strength Structural Bolts - ASTM A325N Type 1, or A490
- Washers - Hardened steel, ASTM F436
- Nuts - Heavy hex, ASTM A563
- Welded stud anchors shall be headed arc-welded mild steel studs conforming to ASTM A108, Type B having minimum yield strength of 51,000 pounds per square inch (psi) and a minimum tensile strength of 65,000 psi.
- Anchor Bolts - ASTM F1554 Hex Head, Grade 36 or Grade 55
- Electrodes for Welding - Electrodes shall be E70XX 70ksi tensile strength, minimum.
- All structural steel shall be hot-dipped galvanized in accordance with ASTM 123 and all mill certifications shall be available. Structures shall be fabricated such that double dipping is not required.
- Bolted connections shall be ASTM A325 with hardened washer and heavy hex nuts installed as snug-tightened in accordance with the Research Council on Structural Connections Specification for Structural Joints Using ASTM A325 or A490 Bolts.
- All welding shall comply with the requirements of AWS D1.1, Structural Welding Code - Steel. Welders and welding processes shall be qualified in accordance with AWS D1.1.

2.14.12 Foundations and Concrete Work

The Contractor shall furnish all labor, equipment, materials and services to layout, design and construct all foundation and concrete work required for the Project. The Contractor shall provide foundations for all equipment and structures, as appropriate, including but not limited to shelters, containers, buildings, transformers, switches, breakers and instrument transformers.

The design and construction of all foundations shall be in accordance with the requirements set forth in M1-02-01 (General Civil Requirements), ACI 318, and Oregon Structural Specialty Code. All concrete exposed to weather or in contact with soil shall be designed to be compatible with the life of the Project.

The appropriate manufacturer shall specify the quantity, size, and location of anchor bolts for enclosures and equipment per seismic qualification reports. Embedded steel items shall be hot dip galvanized. Anchor bolts and embedded steel items subject to corrosive action shall be fabricated from stainless steel.

Concrete shall be batched, mixed and delivered in accordance with the requirements of ACI 301. Reinforcing shall be detailed and fabricated in accordance with ACI 315. Details of concrete reinforcement not covered in ACI 315 shall be in accordance with the CRSI manual. Concrete placing methods shall conform to the requirements of ACI 301, 304, and 318.

The Contractor shall provide the services of an independent testing agency to perform tests on concrete material such as compressive strength, slump, concrete mix designs, during the course of the Work. Testing, evaluation and acceptance of concrete shall be done in accordance with the requirements of Chapters 16 and 17 of ACI 301. Any concrete that does not meet the requirements shall be replaced with no increase to the Purchase Price.

2.14.13 Mechanical

All exposed surfaces (inside or outside) of ferrous parts shall be thoroughly cleaned, primed, and painted or otherwise suitably protected to survive outdoor conditions for the design life of the Project.

The building housing the energy storage system and any other outdoor enclosures or shelters shall be waterproof and capable of surviving, intact, under the Site environmental conditions for the design life of the Project. Flat Roofs are not allowed – minimum roof slope shall be 0.25 inch per linear foot.

Components mounted inside of the building and any other enclosure shall be clearly identified with suitable permanent designations that also shall serve to identify the items on drawings provided.

- The Project shall include an HVAC, thermal management system, and/or ventilation system for the enclosure(s) housing the energy storage system(s) and control shelter which shall be seismically anchored. All design shall be in accordance with seismic design requirements as specified in Section 1.4 of this Specification.
- The Project shall be designed to maintain component temperatures within design limits for all modes of planned Project operation. The HVAC system shall be sized to maintain ambient temperature and humidity in the enclosure to within the limits specified by the battery manufacturer during all operating modes and ambient conditions.
- HVAC communications and control technology shall make use of the best Industry Standard components and be compatible with the Owner's existing environment for substation communications infrastructure.

2.15 Quality Assurance / Quality Control

2.15.1 Quality Control Program

- The Contractor shall establish, implement, and maintain a comprehensive QC Program, which shall be reviewed for approval by the Owner prior to implementation. This program shall include provision of a qualified, on-site Quality Assurance / Quality Control (QA/QC) support staff for the duration of the Project.
- The QC Program shall clearly establish a QA/QC Manager and/or staff with the responsibility and authority to inspect the Work, to enforce the quality requirements of the Statement of Work and the Agreement, and to verify the effectiveness of problem resolutions and corrective actions.
- The QC Program shall be capable of assuring that the design, construction, purchasing, manufacturing, shipping, storage, testing, inspection and examination of all equipment, materials, procedures, and services shall comply with the requirements of the Agreement and building code requirements. Reports generated under the QC program must be submitted to the Owner within three days of receipt.

- The Contractor shall provide all equipment, materials, and labor required to perform all Work in support of QA/QC. As a minimum, this applies to soil density, concrete, welding, and any laboratory tests. Any Subcontractors or third-party inspectors hired by Contractor to perform any Work in support of QA/QC shall be subject to the approval of the Owner.
- The Owner shall have the right to independently review and inspect all Work associated with the Project that occurs or will occur at the Site. This may include review and inspection by third parties and contractors of the Owner.
- The Owner shall have the right to independently review and inspect any Work or equipment associated with the Project that has been previously developed, constructed, or manufactured. For any work, equipment, or materials that are stored outside the Project location (e.g., off-site storage facility), the Contractor shall provide Owner will reasonable opportunities to inspect such items, including any affiliated documentation. This may include review and inspection by third parties and contractors of the Owner.

2.15.2 Quality Assurance Manual

The QC Program shall consist of one or more bound sets of documents comprising a single Quality Assurance Manual. The form and format of the Quality Assurance Manual is at the discretion of Contractor and its Subcontractors. Upon review and final approval by the Owner, it shall become the sole guide for Contractor and all its Subcontractors for quality performance of all Work on the Project. The content of the Quality Assurance Manual shall include written descriptions of QA/QC policies, procedures, methods, instructions, exhibits, or other quality assurance descriptions. An uncontrolled copy of Contractor's corporate QC manual shall be provided to the Owner Representative. The Owner shall always have access to all QA/QC documentation and shall be provided copies upon request.

The Contractor's Quality Assurance Manual shall include, at a minimum, control procedures or methods to assure the following:

- The establishment of on-site QA/QC staff.
- A plan for receipt inspection, in-progress inspection, examination, and testing of the equipment and material installed by Contractor.
- A description of the authority and responsibilities of the persons in charge of the quality assurance program.
- Current and accurate maintenance of design documents, drawings, specifications, quality assurance procedures, records, inspection procedures, and purchase control documents.
- Conformance of purchased materials, equipment and services to the requirements of the Agreement.
- Proper performance of receipt and in-process inspections as well as equipment examinations, testing, corrections as well as checkout procedures.
- The inclusion of adequate inspection and quality of all Contractor's subcontracted work and shop fabricated components.
- Shop inspections are performed and documented at an adequate frequency rate.

- Assurance that the quality of all special processes such as welding, and any other nondestructive testing is properly inspected, verified, and documented.
- Assurance that the proper methods are employed for qualifying all personnel performing welding and non-destructive testing.
- Assurance that inspection hold points are identified and monitored in coordination with the Owner Representative.
- All deviations and non-conformance will be communicated to the Owner in writing within three days.

2.16 Required Training Courses

The training courses described below, with accompanying written text, shall be a live presentation at an Owner facility with the Owner having the right to video tape the training course. Such taped training will be used only for training of new personnel and will be subject to confidentiality agreements, and other protections of Contractor's Intellectual Property. The training course shall cover all aspects of installing the Project, a pictorial breakdown of the energy storage subassemblies, procedures related to emergency response (ruptured modules, fire, etc.), and operation, maintenance and control of the Project.

2.16.1 General

The Contractor shall provide training for the Project as specified below. The Contractor shall determine the content and duration for each training session. The suggested class durations in this Specification are meant to illustrate the level of training expected. Performance evaluation testing of all trainees (i.e., a written test) is required for all classes except the orientation training.

2.16.2 Orientation Training

The Contractor shall provide two orientation training sessions. It is anticipated that each session will last half a day. These sessions shall be suitable for managers, supervisors, professional and technical personnel. Each session will be limited to a maximum of 20 people.

The orientation training sessions shall be scheduled before commencing Acceptance Testing. An outline for this orientation training shall be submitted to the Owner 90 days ahead of the actual date of training. Approval of this outline shall be obtained from the Owner. The Owner will provide comments and/or approval at least 30 days before the scheduled training date.

2.16.3 Operator Training

The Contractor shall provide the necessary training in proper operation of the Project and related equipment. This training shall be conducted after successful completion of the Acceptance Testing, but before system commissioning. It is anticipated that this session will last one (1) to two (2) days. This session will be limited to a maximum of 20 people. Emphasis shall be placed on hands-on operating experience interspersed with critical background as necessary, including switching procedures and emergency response training.

2.16.4 Maintenance and Diagnostic Training

The Contractor is responsible for providing necessary training on energy storage and inverter diagnostic software which includes a set of the necessary cables to diagnose these issues. This training shall be completed onsite using the Owner's field personnel equipment. Documentation of the software and steps needed to communicate with various equipment will be supplied by the vendor.

2.16.5 Emergency Planning and Training

The Contractor is responsible for providing emergency planning and training so that operations personnel and emergency responders can effectively and safely address foreseeable hazards associated with on-site systems. Emergency planning and training shall include procedures for safe shutdown; alarm response procedures; emergency response procedures following fire, explosion, or release of toxic chemicals; and any other procedures as determined necessary by the AHJ to provide for the safety of occupants and emergency responders.

This training shall be provided in a separate and distinct document such that Owner may provide periodic training to local fire department personnel. This must include any handouts, videos, checklists and all other materials required for a comprehensive training product.

3.0 FUNCTIONAL REQUIREMENTS

3.1 General

The Project shall serve multiple purposes on the Owner's system for bulk energy services, ancillary services, and distribution level services. Each service is described as a control mode. These modes will all be supported within the system capabilities and the system's self-protection requirements. Most of the control modes are simply accomplished by the Owner sending active power (P) and reactive power (Q) setpoints via the SCADA interface while the system is in PQ mode. These control modes are described in this section for the Contractor to understand the expected operation of the system and potential impacts on maintenance, guarantees and system longevity. Only two services are accomplished through built-in applications within the Contractor's Site Controller. These two services are frequency/watt control (sometimes called frequency support or freq/watt) and Volt/VAr support (sometimes called voltage support).

Dispatch of the system will be limited to 2 full charge/discharge cycles per day and 365 full charge/discharge cycles per year.

All services that the Owner dispatches through P and Q commands will have ramp rates unique to that service; those ramp rates being controlled by the Owner. The P and Q setpoints will be sent to the system along the appropriate ramp curve, not as a step change. The Supplier will provide four data tags for the Owner to select the overall system maximum ramp-up and ramp-down rates (one data tag input for ramp up, one data tag input for ramp down and two data tags for feedback for each of the two ramp inputs). These four data tags will be shared with the Owner's SCADA system to be used by the Owner, subject to the Project's internal ramp limits for safety and system longevity. These two ramp rates will be used by the Owner as maximum ramp rates for charging and discharging. In dispatching the system, the Owner will send setpoints that ramp up or down and the Contractor is expected to respond to these commands no slower than the maximum rates established.

As well as ramp rates, all Customer PQ commands will be limited by the Contractor's site controller's Contractor-specified SOC limits and power limits to avoid damage to the Project.

Description of Various Ramp Rates and Their Hierarchy	
Project Internal Ramp Rates	Maximum ramp rates established by the Contractor and hard-coded into the system. These ramp rates are for ultimate safety and protection of the Project. They are not adjustable by the Owner.
Owner-Selectable Ramp Rates	Maximum ramp rates established by the owner. They are four data tags within the Project that can be written-to and read-from the Project's Project Site Energy Controller by the Owner. These ramp rates cannot exceed the Project Internal Ramp Rates.
P and Q Setpoint Ramps	These ramps are built into the P and Q setpoints sent by the Owner. If they should exceed the Owner-Selectable ramp rates, the Project will default to the Owner-Selectable ramp rates.

At any time during operation, if the system is responding to abnormal conditions as described in IEEE1547-2018 Clause 6, the system will respond in accordance with that standard without regard to any established ramp rates.

Termination of operating modes due to reaching the discharge limit shall take into account the ramp down energy required.

3.2 Control Modes

The following sections describe the control/operational modes and sources of commands for the Project. Contractor shall work with the Owner to ensure that the appropriate command and source hierarchy are enforced by the Project.

3.2.1 Offline

The Project shall open the breaker/contactor(s) on the DC bus, inverter AC output breaker/contactor(s), and de-energize non-critical power supplies. It should physically isolate the inverter output from the grid, not just provide a zero output, to prevent interaction with the grid (nominal auxiliary load contactors may continue to serve these loads). This mode includes both normal shutdown and system trips requiring reset. The entire system must be capable of remote reset. The control system shall initiate the offline mode under the following conditions and remain in the offline state until a reset signal, either local or remote, is initiated.

- Emergency trip operation
    - AC circuit breaker trips that isolates the Project from the grid such as direct transfer trip or other system protection
    - Smoke/fire alarm and suppression operation

3.2.2 Standby

The Project controller should close the inverter AC output contactor after synching, but neither charge nor discharge, and only draw necessary auxiliary load or power required to maintain a requested SOC (if requested). Under certain conditions, the system may spend long amounts of time in standby mode. The Project is expected to maintain a state of charge of 100% (or other SOC setpoint as provided from the Owner's controller) and be prepared to respond to a signal for P or Q dispatch within the specified time. The Project controller will maintain a requested SOC within +/-1%.

3.2.3 Contingency Reserve

The Project must respond from an idle state to a request for contingency reserve within two seconds of receiving the command. From that time, the facility will ramp up at a rate of at least 20MW per minute until the full rated active power output of the system is achieved. The full rated active power output shall be maintained according to the Customer's P setpoint. If the Project becomes depleted of charge prior to the completion of the service and the Customer's P setpoint is not reduced, the Project will ramp-down and go into standby mode. It will not recharge until the Customer sends a P command with a negative polarity.

3.2.4 Fast Frequency Response (FFR)

This dispatch is controlled by a central controller in the Owner's SCADA system. When this service is dispatched, it is a result of the Owner's system sensing a drop in frequency of a pre-defined magnitude. In this situation, the Owner's RTU will send a single bit that will be used to trigger the FFR application. The appropriate response from the site controller is to immediately ramp to a FFR setpoint also coming from the Owner's RTU. This setpoint is additive to whatever the P value was at the time. After three minutes the output will be ramped back to where the original P setpoint was.

The Project must respond from a standby state to a request for frequency response within two seconds of receiving the command.

3.2.5 Active Power Regulation in Response to Area Control Error (ACE)

The Project shall charge or discharge in response to the Owner's P setpoint, received from the Owner's RTU.

The Project must be capable of performing regulation according to Area Control Error (ACE) signals. The control for this service will originate from the Owner's RTU. The Project must be able to respond to these MW signals within four seconds or less. Response is defined as the time from the Project controller receiving a MW setpoint until that steady-state MW output is achieved.

The Project shall be capable of both positive (supplying) and negative (absorbing) active power setpoints, which may be of any magnitude up to 100% of the system's real power rating. Over time, these active power setpoints are intended to be energy neutral (no net gain or loss in energy). In the event battery SOC is at a level where the requested setpoint (either positive or negative) cannot be met, the Project controller shall respond only to active power setpoints for the polarity it can achieve. The Project will resume responding to MW setpoints of both polarities once the battery SOC has returned to an acceptable range.

Contractors must stipulate clearly how the thermal limitations of their system would affect this service.

3.2.6 Reactive Power Regulation

The Project will respond to reactive power setpoint requests from the Owner's plant controller within four seconds. Setpoints may be constant (fixed) or variable reactive power outputs in order to maintain voltage using closed-loop proportional integral control (an application residing within the Owner's site controller). The Project must be able to regulate reactive power to within +/- 1% for reactive power setpoints between 10% and 100% of the Project's reactive power nameplate rating.

The only limitation for providing this service must be the overall MVA rating of the Project, with active power setpoints having precedence over reactive power setpoints.

3.2.7 Manual/HMI

The Project shall be capable of being operated manually from a local operator HMI. All Project functionalities shall be available via this HMI including all control modes, operating parameters or setpoints and monitored information/status.

This operator HMI shall be capable of disabling other control modes from operating and signals being received from the Owner's other integrated systems in order to operate solely in local mode.

3.2.8 Frequency/Watt Service

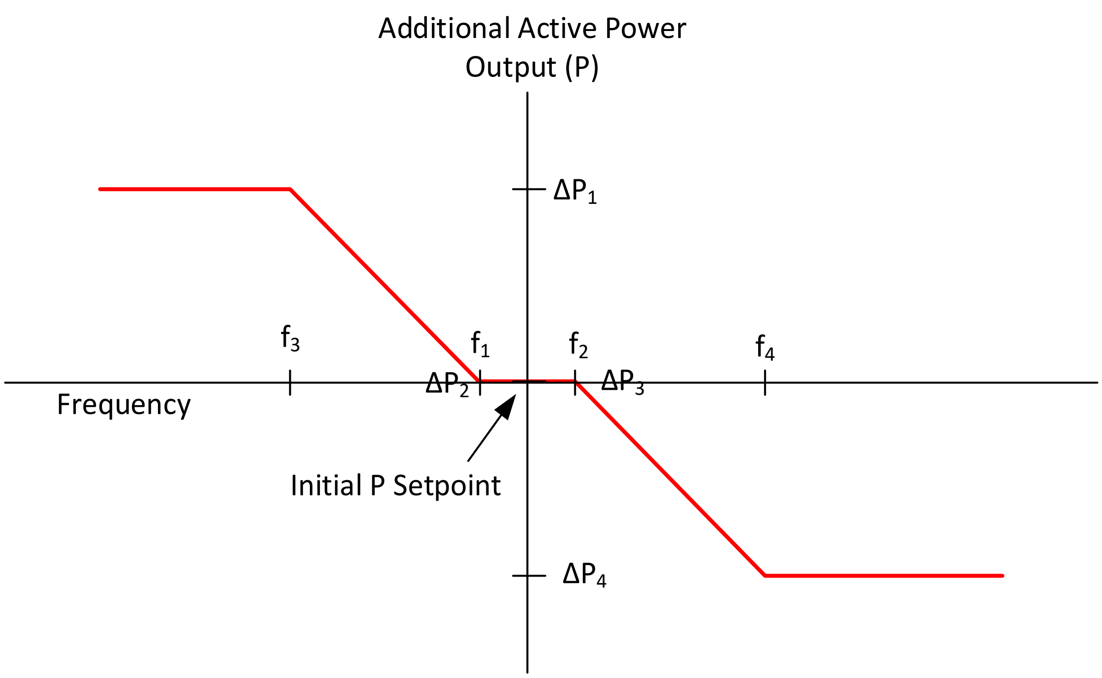
This control mode should be a feature of the Contractor's SEC. This mode should operate as described in IEEE 1547 Clause 10 – Interoperability.

Frequency support shall be an open loop response to frequency fluctuations from 60Hz as measured at the PCS terminals. The inverter real power response is proportional to the frequency offset from the frequency deadband and the defined freq/watt curve. The total system output is the sum of the active power resulting from the P setpoint and the delta power provided by frequency support.

If the frequency drops below the limit value defined by f2, the battery algebraically increases active power output (increases discharge power or reduces charge power) according to a slope defined by the Owner-configurable table. If the frequency exceeds the limit defined by f3, the battery decreases discharge or increases charge power according to a slope defined by the $\Delta P1/f4$.

Frequency support is enabled by the Owner's site controller sending a "1" to the "FreqActive" register.

Parameter	Description	Units*	Example	Range*
FreqActive	Activate frequency support mode	-	0	[0-1]
FreqLow (f_1)	Low frequency deadband setpoint	mHz	59.964	Fnom – 4Hz
FreqHigh	High frequency deadband setpoint	mHz	60.036	Fnom + 3Hz
FreqLowDelta	Frequency delta for low frequency	mHz	100	[0-2000]
FreqHighDelta	Frequency delta for high frequency	mHz	100	[0-2000]
PowerLowDelta	Power change for low frequency support	Watts	5000	≥0
PowerHighDelta	Power change for high frequency support	Watts	5000	≤0



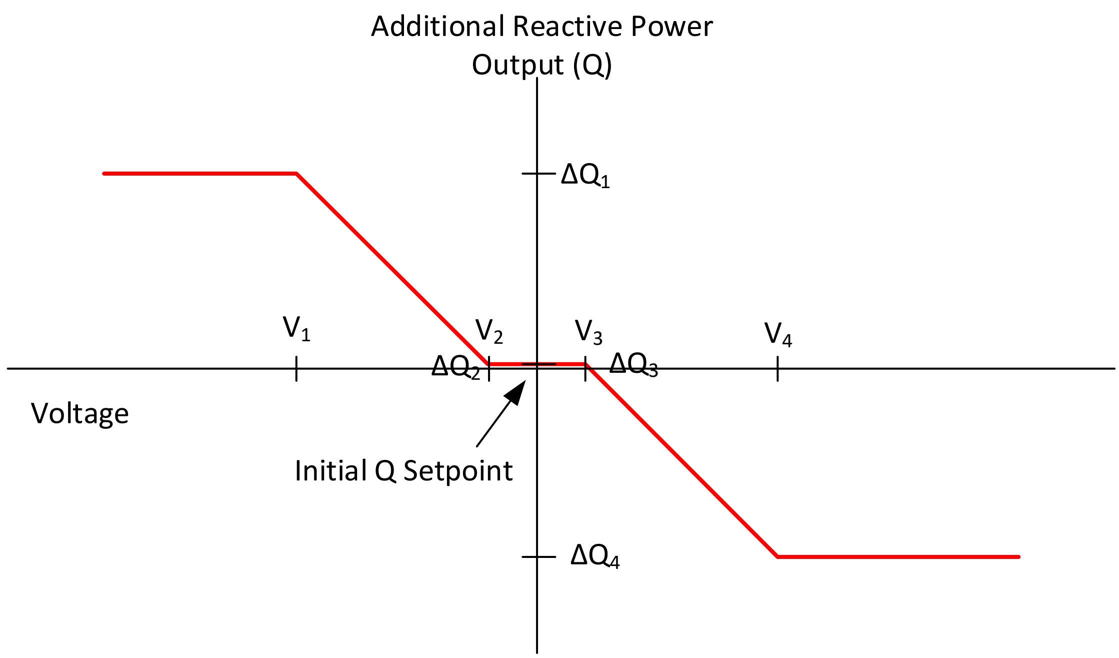
3.2.9 Voltage Support (Volt/VAr) Service

As a default, this mode should operate as described in IEEE 1547 Clause 10 – Interoperability. Alternatively, if the Contractor can achieve the same result with alternative means, that is acceptable.

Volt/VAr service shall operate as an open loop response to voltage deviations from nominal system voltage as measured at the inverter terminals. The inverter's reactive power response shall be proportional to the voltage offset from the nominal voltage as defined in a user-defined Volt/VAr table. Contractor shall make data tags available to Customer's SCADA system to populate this table. The total system reactive power output shall be the sum of any existing Q setpoint and the additional reactive power requested by the Volt/VAr service.

The Customer shall be able to configure the Volt/VAR slope through a parameter table such as that shown below:

Parameter	Description	Units	Default	Range
Volt/VAr Service Active	Enable Volt-Var mode	-	0	0-1
V1	Low voltage setpoint 1	0.1%	1000	0-2000
ΔQ1	MVARs at low voltage setpoint 1	0.1%	0	-1000 – 1000
V2	Low voltage setpoint 2	0.1%	1000	0-2000
ΔQ2	VARs at low voltage setpoint 2	0.1%	0	-1000 – 1000
V3	High voltage setpoint 3	0.1%	1000	0-2000
ΔQ3	VARs at high voltage setpoint 3	0.1%	0	-1000 – 1000
V4	High voltage setpoint 4	0.1%	1000	0-2000
ΔQ4	VARs at high voltage setpoint 4	0.1%	0	-1000 –



4.0 TECHNICAL REQUIREMENTS

4.1 General

The Project shall include the ESS, PCSs (inverter(s)), pad-mount transformers, cabling, shelters, metering, all associated control and communication interface systems, all switchgear and other interconnection equipment and all auxiliary loads necessary to support its operation to the point of interconnection with the utility.

All loads necessary to operate and protect the Project, such as controls, cooling systems, fans, pumps, and heaters, are considered auxiliary loads internal to the ESS.

The Point of Interconnection (POI) shall be defined per the Scope of Work and indicated in Appendix B which shall be submitted by Contractor at the time of bid submittal.

4.2 Storage Capacity

The Project shall be rated in terms of net delivered power and energy to the POI. All system loads and losses, including wiring losses, transformer losses, losses through the contactor/static switch, power conversion losses, auxiliary loads, and chemical/ionic losses are considered internal to the Project and ratings are net of these loads and losses as measured to the POI.

In such cases where auxiliary loads (such as cooling systems) are periodic in nature, ratings may be described for conditions in which these loads are active in the worst-case conditions.

The Contractor shall scale the reported SOC of the ESS so that 0-100% represents the maximum range of operational (usable) energy storage capacity available to the Owner regardless of the actual SOC of the system. A reported 0% SOC shall indicate that no further discharge of the system is permitted, and a reported 100% SOC shall indicate that no further charging of the system is permitted. This range shall permit the Owner to fully realize the rated energy storage capacity of the system (i.e. for a 1.0-megawatt hour [MWh] system, the Owner shall be able to discharge 1.0 MWh of energy when discharging from a reported 100% to a reported 0% SOC) as measured at the POI.

4.3 Ratings

Following are fundamental Project unit ratings. Note that power, energy, and ampacity ratings apply through the full operating temperature range, as defined for the Site unless otherwise noted.

4.3.1 AC Voltage

Nominal interconnection voltage is 12.47 kV [±5%] for Projects connected to Owner’ primary system.

4.3.2 Round-trip Efficiency

The roundtrip AC-AC energy efficiency, measured at the POI, shall be provided and include parasitic and auxiliary losses under worst-case conditions prescribed in the FAT Plan.

The calculation is as follows:

$$\boldsymbol{\eta = \frac{kWh_{out}}{kWh_{in}} \times 100\% = \frac{(rated\ discharge\ power) \times (discharge\ time)}{(rated\ charge\ power) \times (charge\ time) + losses} \times 100\%}$$

In which the discharge time is from a fully charged to fully discharged energy storage, and charge time is from a fully discharged to fully charged energy storage. If the auxiliary power is provided by a separate connection from the energy storage, these measured values should be reflected in the losses term in the equation.

4.3.3 Parasitic Losses

The total ESS unit losses shall be determined for standby operation, including power electronics and any environmental controls such as HVACs.

4.3.4 Self-Discharge

Contractor shall provide self-discharge characteristics.

4.3.5 Basic Insulation Level

The ESS AC system equipment shall have a Basic Insulation Level (BIL) in accordance with the IEEE for each piece of equipment.

4.3.6 Inrush Capability

It may be advantageous to the Owner for the Project to have short time overload capabilities. This may occur for power system disturbances in which both real and reactive power is required for a short period of time to control both frequency and voltage excursions.

The Contractor shall provide a curve showing the inherent overload capability (if any) of the Project as a function of time. It is not a requirement of the Specification to design specific overload capability into the Project.

For projects that include islanding, the ESS shall have capability for 1.5 x rated MW and 1.5 x rated MVA for one minute. This inrush duty will be four times per hour on top of continuous, full load.

4.3.7 Auxiliary Voltage

Auxiliary voltage will be site specific.

4.3.8 Power and Energy

System ratings are defined in kVA (AC) or MVA (AC) and kWh (AC) or MWh (AC) as measured at the POI. In all instances the reference point of applicability (RPA) is the POI. Contractor must request meter data at the POI which can be provided to the Contractor via the Customer's SCADA system.

Project reactive power capability must comply with IEEE 2800 Clause 5.1.

4.3.9 Design Ambient Temperature Range

System shall be designed for an ambient temperature range of 0°F (min) to 118°F (max).

4.3.10 Audible Noise

The maximum sound level generated from the Project and any associated equipment supplied by the Contractor under any output level within the Project operating range, shall be limited to levels specified by Applicable Laws, including any applicable local noise ordinance(s). The Contractor shall comply with all Applicable Laws that may apply to the Project installation as determined by the jurisdiction applicable to the site. Noise abatement or mitigation solutions must be permanent; permanent meaning the life of the project. Contractor may not use temporary means to satisfy project permitting that are of risk of becoming superceded or obsolete during the project life.

The audible noise level in the Project control room if separate from areas housing inverters, cooling equipment, etc. shall meet OSHA requirements for normally occupied areas.

The Contractor shall make audible noise measurements before and after commissioning of the Project for the purpose of verifying adherence and compliance with the local ministerial ordinance and requirements. The measurements shall be made at various locations using a Type 1 sound level meter that complies with the requirements of ANSI S1.4-1983 “American National Standard Specification for Sound Level Meters.”

4.3.11 Broadband Interference

The Contractor shall take necessary precautionary measures to ensure that there will be no mis-operation, damage or danger to the Project due to broadband interference and effects. The Contractor shall ensure that there are no discharge sources from the Project and related equipment that could cause interference with radio and television reception, wireless communication systems, or microwave communication systems per the 47 CFR Part 15. The Contractor shall propose any necessary mitigation to ensure that communication is not adversely affected.

The Contractor shall make measurements before (or with all equipment de-energized) and after commissioning of the Project for the purpose of verifying compliance with the broadband interference requirements.

All broadcast signals, radio noise, television interference and broadband interference measurements shall be made with instruments that comply with the latest revision of ANSI C63.2, “American National Standard for Electromagnetic Noise and Field Strength Instrumentation, 10 Hz to 40 GHz - Specification.” IEEE Standard 430, “IEEE Standard Procedures for the Measurement of Radio Noise from Overhead Power Lines and Substations” defines the measurement procedures that shall be used.

4.3.12 Interference and Harmonic Suppression

The PCS shall not produce EMI that will cause mis-operation of instrumentation, communication, or similar electronic equipment within the Project or on the Owner system. The PCS shall be designed in accordance with the applicable IEEE standards to suppress EMI effects.

The Project must meet the harmonic specifications of IEEE 2800 Clause 8 and IEEE 519 and comply with requirements outlined in the Energy Storage Integration Council (ESIC) technical specifications spreadsheet. Harmonic suppression may be included with the PCS or at the Project AC system level. However, the Contractor shall design the Project electrical system to preclude unacceptable harmonic levels in the Project auxiliary power system.

4.4 External AC Power Interface(s)

4.4.1 Termination

All terminations and locations of terminations shall be pre-approved by the Owner and specified in the appropriate submitted drawings. The Project shall comply with any applicable owner interconnection standard.

4.4.2 Isolation/Disconnect

An interconnection isolation disconnect device shall be placed directly on the line side of each metering section. The disconnect device shall be lockable and have a visible break or visible open. The device does not have to be rated for load break nor provide over-current protection. The Owner shall have full access and control over this device.

A LV source side isolation contactor shall be provided. The disconnect breaker shall be lockable and have a visible break. It shall be capable of breaking the full rated power of the system. The contactor will be operated by SEC and will also have provisions to be operated manually. The utility will have full access and control over this device.

4.4.3 Use for Auxiliary Power

The auxiliary power system shall include, but is not limited to, all step-down transformers, breakers, fuses, motor starters, relaying, uninterruptable power supplies, panels, enclosures, junction boxes, conduits, raceways, wiring and similar equipment, as required for the Project operation.

All uninterruptable power supplies must be provided with a Modbus Ethernet connection for monitoring.

The aux transformer will require a remote mounted 13-jaw electric meter socket to accommodate a Schneider Ion 8650 revenue meter. This meter must have a Modbus Ethernet connection to the Customer’s site controller.

4.4.4 Power Quality Metering and Telemetry

Contractor shall provide its own Current Transformers (CT) for protection and internal metering, and controls for Project operation. Contractor to provide local utility compliant metering and telemetry. Contractor to provide Potential Transformer (PT) connection points for synching and telemetry. Contractor to provide one revenue grade power quality meter installed on the line side of the main breaker to validate system performance. This meter must have a Modbus interface via Ethernet connection.

4.4.5 System Protection Requirements

Contractor shall adhere to rules and regulations described on the Owner's Electric Distribution System Interconnection or Generation Interconnection Handbook if available. For the avoidance of doubt, the requirements of the applicable Interconnect Handbook shall apply to all aspects of the project and not just the system protection. If Owner Handbook is unavailable the contractor shall adhere to IEEE and Manufacturer device setting recommendation for protective system settings.

Protection and coordination for the "plant-side" system including batteries, DC combiner panels, inverters, AC combiner panels, transformers, auxiliary systems, and switchgear (where applicable) shall adhere to IEEE 242.

Protection relays for the interconnection shall be utility grade and shall meet the minimum requirements specified in IEEE C37.90 (latest edition) including requirements for EMI and surge withstand according to applicable standards for the intended location of the Project. A complete protective relaying system based on Industry Standards shall be a part of the AC system. The protective relaying and metering shall be integrated with the Project control system and a communications channel provided to the Owner's SCADA system. However, integration into the Project control system shall not circumvent normal protective relaying functions.

All protective equipment and schemes shall be properly coordinated with the Owner protection engineering department. The Contractor shall use Schweitzer Engineering Laboratories (SEL) microprocessor-based protection equipment to the extent practical. When SEL microprocessor-based protection equipment is not practical, Owner shall approve of equipment Contractor proposes to be used. The interconnection relay shall be a SEL relay with Mirrored Bits capability (either an SEL 351 or SEL 751). The low side bus and cable shall be protected by multifunction feeder protection relays. Testing of protection equipment shall be conducted by International Electrical Testing Association (NETA) certified technicians. The NETA certification number of the tester shall be documented on all test reports.

4.5 Coordination of Controls

The Contractor shall provide a fiber optic communications pathway specifically for mirrored bits communications with the Owner's relaying at the interconnection distribution switch. This communications pathway will provide breaker status, permissions to island, black start and operate in parallel as appropriate.

4.6 Instrument and Control Wiring

In general, and where practicable, control and instrumentation wiring shall be designed and installed to minimize any and all electrical noise and transients. All cabling shall be new and continuous for each run; splices are not acceptable. All conductors shall be copper.

All cabling which may be exposed to mechanical damage shall be placed in conduit, wireway, overhead tray, or other enclosures suitable to the Owner. Wires shall have identifying labels or markings on both ends. The labels shall identify the cable tag, and opposite end destination. Each wire in the system must have an accompanied drawing and location reference.

Control and instrumentation wiring shall be separated from power and HV wiring by use of separate compartments or enclosures or by use of separate wireways and appropriate barrier strips within a common enclosure as required by the NEC.

Project and PCS control and instrumentation system wiring shall be bundled, laced and otherwise laid in an orderly manner. Where cable is in wire trays, waterfalls shall be used, as necessary. Wires shall be of sufficient length to preclude mechanical stress on terminals. Wiring around hinged panels or doors shall be extra flexible (Class K stranding or equivalent) and shall include loops to prevent mechanical stress or fatigue on the wires.

Cable insulation material shall be thermoset composition rated for 90˚C during normal operation. Insulation and jackets shall be flame retardant and self-extinguishing and shall be capable of passing the flame test of IEEE Standard 383 or IEEE 1202. Raceway and cable systems shall not block access to equipment by personnel.

Where appropriate, Fiber Optic Cable used for instrument and/or control shall be ruggedized indoor/outdoor breakout, riser rated, orange jacket, four fiber, 50/125um MM giga link 600 fibers, 2.5 mm, RoHS, standard strip.

Ethernet cable that is run in conduit underground must be rated for wet locations or direct bury. No Ethernet cables shall be actually direct-buried.

4.7 Modular Replacement

The Project PCS, control, batteries and current sensors shall be connected in a manner that enables field replacement. It is expected that most maintenance will be accomplished while maintaining partial service. The physical and electrical arrangement shall permit module replacement with the isolation breaker/contactor closed and the PCS disconnected. For CTs, this means that shorting test switches must be used.

Owner shall not be required to provide additional space or resources to accommodate the battery module replacement or supplementation. Contractor shall reserve the appropriate spacing and clearance per NESC into the design of the Project to accommodate battery module replacement and supplementation.

4.8 Physical Characteristics

The Project shall meet all applicable OSHA, NEC, IEEE, ANSI, and NFPA requirements for electrical and fire safety.

The Project shall be designed to minimize footprint and volume. The Project may also be designed to include subsurface components or modules, provided relevant operating and environmental factors normally addressed for submersible equipment are considered to assure full life-cycle performance requirements are met.

The Project components located outdoors shall be contained within weatherproof, tamper resistant, metal enclosures suitable for mounting outdoors on concrete pads with a minimum NEMA 3R rating. NEMA 3R: Types 3R, 3RX: Rain-tight, sleet-resistant. Indoor or outdoor use. Same protection as Type 1, but adds a degree of protection against ingress of falling dirt, rain, sleet and snow; also protects against damage due to external ice formation. Rust-resistant. The "X" designation indicates corrosion-resistance.

Any enclosures shall be dust tight to at least the NEMA 3R rating, except as designed to allow forced air exchange with the atmosphere.

Project Modules PCS, and controls shall be accessible and removable for replacement. The Project shall be designed to operate with minimal maintenance for at least five years.

A nameplate shall be provided including:

- Manufacturer Name
- Connection diagram
- ESS ratings; Power, energy, voltage, BIL
- Specimen data; serial number, date of manufacture
- The nameplate shall meet the requirements of IEEE C57.12.00

All necessary safety signs and warnings as described in ANSI Z535-2002 (entire series from Z535.1 through Z535.6), NEC, and NFPA 855 shall be included on the building, shelter or each enclosure. All necessary signs and warnings for identification of hazardous materials as described in NFPA 704 shall be included on the building, shelter or each enclosure.

4.9 Cycle Life

The ESS must be designed to achieve a minimum lifetime of 20 years for continuous operation with minimum scheduled downtime for inspections and maintenance. End-of-life is defined as when the ESS reaches 80% of the nameplate rated capacity at the time of installation. If the ESS is subject to capacity degradation, the design must accommodate future augmentation as required to maintain nameplate rated capacity, taking into consideration the specified operating profile. See the ESIC technical spreadsheet in Appendix G for cycle life requirements to various depths of discharge over the anticipated ESS lifetime.

The Contractor shall provide a graph or set of graphs that displays the relationship between depth of discharge, discharge energy throughput, operating temperature, C-rate, resting state-of-charge, and other relevant parameters and the corresponding capacity degradation experienced by the ESS.

Cycle counting shall be accomplished by applying a filter for each of the specified depth of discharge levels or based on other methodology proposed by the Contractor and agreed to by Owner. Contractor shall propose a methodology for tracking all other parameters that effect ESS capacity.

The Project will be designed to provide the equivalent of at least two (2) cycles per day and a maximum of 365 cycles per year.

4.10 Battery Management System

As a subcomponent of the Project, a Battery Management System (BMS) shall be included to manage the operational health of the Project, provide cell-by-cell diagnostics information and assure its safe and optimal performance of the energy storage system as an interconnected asset to the Owner's electrical system. The BMS shall be specifically built by the battery manufacturer for that battery system. If the battery manufacturer uses a third party BMS, the Contractor must provide detailed a description of how that BMS was custom designed for the application. Primary functions include but are not limited to:

- Monitoring:
    - State of Charge
    - State of Health
    - Voltage/Current
        - String
        - Bank (if applicable)
    - Temperature
        - Module Internal
        - Various Ambient
        - Highest cell temperature
        - Average cell temperature
    - Status
    - Contactor status
    - Energy Throughput
- Maximum charge/discharge current or power
- Active Cell Balancing (Passive voltage balancing is not acceptable)
    - Cell voltage
- Warning and alarms
- Internal protective measures
- Logs of operations
- Management of any software versions
- Cyber Security management of the device itself
- Provide data exchange to the SEC
- Contribute to functional safety of overall Project

4.11 Power Conversion System

The PCS shall be listed to UL 1741 Supplement B and shall comply with IEEE 1547-2018 for distribution-connected projects. PCS connected at the transmission level shall comply with IEEE 2800. The PCS must be capable of delivering any combination of active power and reactive power that results in the following equation being true: $\text{apparent power}_{rated}=\sqrt{\text{active power}^2+\text{reactive power}^2}$ and as defined by the inverter P-Q capability curve;

provided that at the system level there may be restrictions on reactive power output if the setpoint is chosen to boost system voltage that is already higher than nominal or reduce system voltage that is already lower than nominal.

The PCS shall be a static device (non-rotational) using solid-state electronic switch arrays in a self-commutated circuit topology. Line-commutated systems or systems that require the presence of utility voltage or current to develop an AC output are not acceptable. Only commercially proven switch technology and circuit designs are acceptable.

The PCS, in conjunction with the Project control system and the BMS shall be capable of completely automatic unattended operation, including self-protection, synchronizing and paralleling with the utility, and disconnect functions.

The control of the PCS shall be integrated with the overall Project control system. However, the PCS also shall include all necessary self-protective features and self-diagnostic features to protect itself from damage in the event of component failure or from parameters beyond safe range due to internal or external causes. The self-protective features shall not allow the PCS to be operated in a manner that may be unsafe or damaging. Faults due to malfunctions within the PCS, including commutation failures, shall be cleared by the PCS protection device(s) or external protection devices. Such faults shall be acknowledged, cleared and reset remotely.

All PCS components shall be designed to withstand the stresses associated with steady state operation, transient operation and overload conditions as required by this Specification. The Contractor shall demonstrate that all relevant aspects of overvoltage stresses have been considered.

The PCS system shall include provisions for disconnection on both the AC and DC terminal(s) for maintenance work. Conductor separation must adhere to the requirements of the Owner’s Generator Interconnection Handbook, the Owner’s Distribution Interconnection Handbook, or IEEE standards and best practices. These disconnecting devices shall be capable of being locked open for maintenance work. Any PCS capacitors shall be provided with bleeder resistors or other such means of discharging capacitors to less than 50 volts within five minutes of de-energization per UL1741 requirements.

The PCS or battery system must have DC bus pre-charging functionality or other means of arc mitigation during switching of the DC disconnect devices.

Outdoor located PCS electronic compartments shall be NEMA 4 at a minimum and the overall enclosure rating shall be a minimum of NEMA 3R. PCS shall meet IEEE 519 and IEEE 2800 for transmission-connected projects IEEE 1547 for distribution-connected projects for harmonic content.

PCS cooling system shall not be susceptible to particle contamination and require minimal scheduled maintenance. The PCS shall be furnished with nameplates or stickers that are suitable for the environment. Nameplates shall be located to be visible with equipment installed and operating. Each nameplate shall indicate the following information:

- Nameplate ratings
- Component name

- Manufacturer’s name
- Serial number
- Year built (or may be found in a reference document based on serial number)

4.12 Site Energy Controller (or Plant Controller)

The Project shall include all necessary software applications and supporting hardware required to meet the specified functional requirements. Software algorithms, external data input capabilities, and user interfaces shall provide for user specified variable input or set point values, as well as external data value streams required by programs directing the Project operations.

The Project shall include the necessary communication and telemetry hardware, and support communications protocols, to effectively provide the required services. No single mode of failure shall result in loss of power to the control and data acquisition module. The control shall include provisions for an orderly and safe shutdown in the absence of utility power.

4.12.1 Operations and Control Functions

The SEC shall be the primary dispatching location for local monitoring and control command functions, and is responsible to perform the following by priority in this order:

- Protect itself (isolate for any internal fault)
- Remain within power constraints (transformer and Project ratings)
- Remain within frequency constraints
- Remain within voltage constraints
- Remain within operating temperature constraints
- Isolate in response to system anomalies
- Charge/discharge Real Power and Reactive Power in response to SEC programs or external commands
- Communicate status and diagnostic data

The SEC shall respond to commands issued remotely or locally, including but not limited to:

- Change Modes (e.g. charge, discharge)
- Startup/Shutdown
- Change Status (enable/disable)
- Reset Alarms
- System Reset/Restart

The SEC shall respond to the following modes of operation:

- Controller must be able to transition from one setpoint within a given mode of operation to another setpoint within the same mode without ceasing operation. Changing of output from an existing inverter setpoint to any other setpoint as a transition step (e.g. returning inverter to 0 output) before executing next command will be considered unacceptable.
- Controller must be able to accept and validate a given setpoint command prior to executing a given operation mode. For example, if the Owner sends a command for the BESS to discharge at 1.0 MW in constant real power output mode, the controller must be able to validate and accept the 1.0 MW setpoint prior to it initiating constant real power output mode. Setpoint validation will vary depending on the control mode command but may include limits associated with state of charge, facility ratings, ramp rates, system operating conditions, etc.
- For Projects that include either black start or islanding functions, the Controller must be able to switch from current source mode to voltage source mode and back via a single remote-control point (“Voltage Source Inverter Mode”), as well as a local point on the Human Machine Interface (HMI).
- Controller must be able to open and close inverter contactors via remote control points. Controller must also be able to open and close inverter breakers if those breakers are motor operated. Controller must be able to reset all applicable system alarms via a remote-control point.
- Controller must be able to conduct real and reactive power operations completely independently of one another until the apparent power limit of the asset is reached.
- Controller shall allow for the prioritization of either real power setpoints over reactive power setpoints or reactive power setpoints over real power setpoints once the apparent power limit of the asset is reached. Prioritization shall be indicated via remote commands from the Owner.
- Controller shall assign a positive sign convention to system real power output information when the system is discharging (real power).
- Controller shall assign negative sign convention to system real power output information when the system is charging (real power).
- Controller shall assign a positive sign convention to system information when the system is injecting reactive power (acting like a capacitor). This should be considered a leading PF.
- Controller shall assign a negative sign convention to system information when the system is absorbing reactive power (acting like an inductor). This shall be considered a lagging PF.
- Controller sign convention for real and reactive power commands shall match the desired convention assigned to system information reporting. In other words, positive real power commands refer to discharging, negative real power commands refer to charging, positive reactive power commands refer to injecting vars, and negative reactive power commands refer to absorbing vars.
- Specific to the Target State of Charge or Energy (SOC) operational mode, the Controller shall ensure the system reaches the commanded SOC setpoint and then not dispatch the system until after the SOC falls outside the commanded SOC deadband.

4.12.2 Loss of Communications

The Project shall remain functional in the absence or loss of communication from the Owner's site controller. The Project shall continue its current mode of operation for a set time period (variable setting, 15-minute default). On expiration of the time, the Project shall ramp to standby mode at a selectable ramp rate (25MW/minute default).

During an interruption to communications, the remote controller will make repeated attempts to re-establish communications at a set time interval (variable setting, default of five minutes). When communications have been re-established, the Project and remote controller shall automatically make any necessary updates or resets to resume performance. Once the system is again ready, it shall remain in standby mode until a new setpoint is sent by the Owner's site controller.

4.12.3 Monitoring, Data Logging, Alarms, and Status

Alarms

- Alarms shall be provided for all critical ESS parameters (see Appendix E for more details).
- Alarms shall be provided for all critical balance of plant system parameters (see Appendix E for more details).
- Owner shall have the ability to acknowledge and clear alarms remotely through the Owner's site controller.
- An alarm log with time stamps shall be provided.
- Details or help screens shall be provided for each alarm.
- An alarm matrix shall be provided to show the relationship and hierarchy of all alarms.

The SEC shall provide relevant status information, for feedback to the utility supervisory control system. The telemetry points should include:

- Operation Control
- Operation Status
- System Information
- AC/DC Status
- Status
- Device Status and Error Codes (Alarms)
- Data Logging:
    - Log of Operations for one year on-site. Life-of-project duration for off-site log.
    - Historical data and trending for one year on-site for a limited set of parameters as agreed with the Owner. Life-of-project duration for off-site data.

4.13 Network Communications

The Project and all its subcomponents required for operation shall be configured to be on its own sub-network, separate from any Owner communications network. All such work shall comply with M1-05-04 (Communication, SCADA, and Metering Facilities Facilities).

- Communication between the energy storage system and any Owner IP network shall be accomplished using a managed gateway between the Contractor-provided energy storage system and any Owner IP-based network (such as a Cooper SMP or SEL RTAC).
- DNP3 is the required communications protocol for external communications between Owner networks and the Contractor's energy storage systems. This must be accomplished without the use of an additional communications gateway device. If the Contractor's SEC cannot accommodate DNP3 protocol, then a different protocol such as Modbus TCP/IP may be allowed. The Owner has the ultimate authority to accept or reject any protocol other than DNP3. A secure, encrypted site to site IP virtual private network (VPN) tunnel may be established between the Owner and the Vendor to allow the Vendor remote access to the Project for monitoring and support purposes. The Owner firewall will deny IP traffic by default and allow authorized IP traffic only by exception. Vendor will provide a detailed list of devices and protocols that require access for remote support.
- Any additional Contractor or Vendor external communications inbound to the energy storage system are prohibited. This includes analog lines, cellular modems, wired or wireless communications circuits, internet connections, cloud, or any other connection methods. If the Contractor requires alternate external communications, these must be submitted to the Owner for review. If the Owner grants approval, it is the sole responsibility of the Contractor to provide, install, secure, and maintain. For cybersecurity purposes, the Owner will not interconnect any Vendor network that has Internet access with any Owner routed IP network or networked device.
- The Project's HMI for control shall be able to be controlled by the Owner electric control centers using a TCP/IP routable protocol specified by the Owner.

The solution shall use wired connections for communications. If the Contractor wishes to include wireless communications in the proposal, these must be submitted to the Owner for review. The Contractor shall provide a list of any proposed wireless communications devices, security methods and encryption standards, the associated protocols, and a list of endpoint devices that would be connected.

Contractor provided communications equipment shall be suitable for the intended purpose and the environment where it is installed. Contractor shall use hardened devices that support extended temperature and humidity where required. For key system communications, the equipment should have built in high availability or redundancy capabilities, or separate redundant devices should be used.

The proposed solution shall provide communications for any required security and fire alarm systems, including fire and first responders, in compliance with all Applicable Laws and Owner standards. The solution shall be capable of communicating with Owner-selected Remote Terminal Unit (RTU) via currently supported protocols and cabling types, as assisted by an Owner Interface.

The Project's Owner-facing network and firewall equipment shall be interoperable with Owner Networks LAN switches, routing, and firewalls, to include static routing, MPLS, OSPF, and 802.1q VLAN trunking.

4.14 Information Security

In addition to any requirements set forth below, all Project-related physical, cyber, information, and other security shall conform to M1-01-07 (Security and Compliance).

4.14.1 Contractor

Contractor shall design the Project to be hardened against willful attack or human negligence using Cybersecurity industry best practices and incorporating technical controls as applicable to the Project as outlined in the NISTIR 7628 Framework. The reference for these controls can be found through the NIST government publications for the Framework NISTIR 7628 – Guidelines for Smart Grid Cyber Security: Vol. 1, Smart Grid Cyber Security Strategy, Architecture, and High-Level Requirements. A summary of these controls is listed in Appendix G.

4.14.2 Application Partitioning

The Contractor shall design the Project to support integration with Role-based Access Controls, as assisted by an Owner Interface. For example, functions necessary to administer databases, network components, workstations, or servers, and typically requires privileged user access. The separation of user functionality from information system management functionality is either physical or logical.

4.14.3 Audit Logging and Reporting Mechanisms

The Contractor shall design the Project to provide logging capabilities. Preferably the logging mechanism is in a standard format like Syslog that can easily integrate with the Owner Security Integration and Event Management system.

4.14.4 Authentication and Authorization Controls

- The Contractor shall design the Project to provide the following authorization controls:
  - Log account access events, such as failed login, login, logout, session timeout.
  - Display an approved system use notification message or banner before granting access to the system that provides privacy and security notices consistent with all Applicable Laws, Executive Orders, directives, policies, regulations, standards, and guidance.
  - Prevent non-privileged users from executing privileged functions to include disabling, circumventing, or altering implemented security safeguards/countermeasures.

4.14.5 Authenticator Feedback

The Contractor shall design the Project to obscure feedback of authentication information during the authentication process to protect the information from possible exploitation/use by unauthorized individuals. For example, do not display a separate error message for an invalid username versus an invalid password.

4.14.6 Baseline Configuration and Configuration Settings

The Contractor shall provide a checklist of security configuration requirements / system hardening requirements for all IT assets deployed as part of the Project, as assisted by an Owner Interface.

The Contractor shall provide an asset baseline configuration for all applicable assets. For network-connected assets, the baseline configuration shall list all open/listening logical ports (both TCP and UDP), the executable that opened that port, and the underlying justification for that port being open. For all assets capable of installing software, the baseline configuration shall list all intentionally installed software and the version of that software, and all applied security patches.

All unused logical ports should be closed/disabled (per equipment capability).

4.14.7 Boundary Protection System

The Contractor shall segment trust zones using a barrier technical control such as a firewall. The barrier technical control shall be configured to deny inbound and outbound network communications traffic by default and allow inbound and outbound network communications traffic by exception.

4.14.8 Cryptographic Key Establishment and Management

The Contractor shall provide certificates that support at least SHA-2, SHA-1 certificates are not permitted. Wildcard certificates like *.example.com are not permissible and certificates must be for specific (list) of sub-domains. All PKI certificates must support SHA-256 or higher. The Contractor will provide cryptographic keys from a Certificate Authority approved by the Owner.

4.14.9 Device Identification and Authentication

The Contractor shall provide an asset inventory containing all programmable electronic devices in the Project. The asset inventory will include the following fields: Device Name, Network Name, IP Address, MAC Address, Building Location, Rack Location, Firmware version / software version, Device Description.

4.14.10 Information Input Validation

The Contractor shall provide a solution that validates user input and network input for malicious content and unstructured data within the Project. For example, user interfaces should not be susceptible to untrusted user inputs.

4.14.11 Information System Backup

The Contractor shall provide the Project with a solution that is scheduled to conduct periodic backups of user and system-level information and protect the confidentiality, integrity, and availability of the backups.

4.14.12 Information system Monitoring

The Contractor shall allow the Owner to monitor network traffic leveraging SPAN ports on switches and routers provided as part of the Project.

4.14.13 Least Functionality

The Contractor shall configure information systems to provide only essential capabilities, open ports, protocols, and services as part of the Project.

4.14.14 Malicious Code Protection

The Contractor shall provide malicious code Endpoint protection software on all assets that support it in the Project and provide a method for updating the software. The Contractor shall configure the Endpoint protection software to perform periodic scans of the information systems and real-time scans of files that are downloaded, opened or executed. The malicious code protection software will block malicious code, quarantine malicious code and send alerts to administrators of the system. Enforced Whitelisting of system software and operation may be considered an alternative to Endpoint protection.

4.14.15 Password-Based Authentication

The information system shall offer provisions for a password-based authentication. These features should include, but are not limited to, the following:

- Enforce password complexity to include case sensitivity, a minimum of eight characters, mix of upper-case letters, lower-case letters, numbers, and special characters.
- Stores and transmits only encrypted representations of passwords.
- Enforces password minimum and maximum lifetime restrictions of specific defined numbers for lifetime minimum, lifetime maximum.
- Prohibits password reuse for 10 generations.
- Allows the use of a temporary password for system logons with an immediate change to a permanent password.
- Employs automated tools to determine if password authenticators are sufficiently strong as related to above criteria of password authentication requirements.

4.14.16 Protection of Information at Rest

As part of the Project, the Contractor shall implement Information Systems that:

- Protects the confidentiality and integrity of information at rest.
- Implements cryptographic mechanisms to prevent unauthorized disclosure and modification of information on information system components.
- Securely stores off-line storage.

4.14.17 Session Authenticity

As part of the Project, the Contractor shall implement Information Systems that:

- Invalidates session identifiers upon user logout or other session termination.
- Generates a unique session identifier for each session with randomness and recognizes only session identifiers that are system-generated.
- Only allows the use of certificate authorities for verification of the establishment of protected sessions.

4.14.18 Transmission Confidentiality and Integrity

As part of the Project, the Contractor shall implement cryptographic mechanisms to prevent unauthorized disclosure of information during data transmission (e.g. VPN Tunnel).

4.14.19 Unique Identification and Authentication

As part of the Project, the Contractor shall provide the means to uniquely identify and authenticate organizational users (or processes acting on behalf of organizational users) such as Multifactor authentication. Shared user accounts shall not be permitted.

4.14.20 3rd Party Assessment

Contractor shall contract information/cyber security scans and penetration tests by an Owner-approved third-party security company, prior to Substantial Completion.

The Contractor will provide the Owner with a copy of the original report from the 3rd party security company. The Owner reserves the right to perform its own internal security testing in addition to the Contractor's testing.

Contractor shall develop a cybersecurity plan that addresses and mitigates the critical vulnerabilities inherent in both the hardware and software that comprise the control and data acquisition systems. The cybersecurity plan will include regular qualified software patches and service packs to Windows and Linux based operating systems, the underlying software and device firmware. The patches will be applied at least every 30 days with an expedited method for highly critical vulnerabilities (Common Vulnerability Scoring System Score of 19). Security related patches should continue to be applied for the duration of the system's useful life.

4.14.21 Portable Media and Laptops

As part of the Project, the Contractor shall disable all mass storage device capabilities for Windows and Linux based servers and workstations (USB drives, SD Cards, CD-ROMs, External Portable HDDs and Floppy disk drives).

Any portable device (or variant) such as process control service laptops will be regularly managed by policy to ensure it is inspected and found to be free from malicious code. Using latest version Endpoint protection with regular updates no older than 30 days. Portable devices will be restricted from connecting to a secondary network while connected to the Process Control network. The Owner may request logs and audit access to review system scans, patching and management tools to ensure compliance. Under no circumstances will the Contractor allow its employees to access any part of the Project with their personal laptop or tablet.

4.14.22 Unused Network Ports

As part of the Project, the Contractor shall disable all unused network ports on switches, routers and firewalls.

4.15 Containment

4.15.1 Lightning Protection

Contractor shall provide a UL Master Label lightning protection system for all buildings, shelters and other structures per the requirements of NFPA 780 and UL 96A. Provide evaluation and risk assessment of remaining Owner and Contractor furnished equipment and enclosures to confirm that remaining equipment is self-protected under NFPA 780 paragraph 7.2.2.

4.15.2 Cooling Systems

The Site temperatures and the effect of temperature on component life shall be considered in developing the thermal design for all components, including the batteries and PCS. There may be several separate heat removal systems to accommodate the particular needs of Project components and subsystems (e.g. PCS, transformers). The heat removal and/or cooling system may include vapor-compression cooling system or other conventional environmental conditioning equipment. Final rejection of all waste heat from the Project shall be to the ambient air.

The cooling system shall be sized for end-of-life battery heat loss information. Total battery heat dissipation shall account for all installed batteries including any provisions for battery augmentation throughout the project life.

Air handling systems shall include filters to prevent dust intrusion into the Project. Exterior wall make-up air inlet louver shall be sized to avoid water penetration. HVAC system(s) efficiency and control requirements must comply with applicable local and national codes. HVAC system(s) for energy storage cooling shall include three or more stages. Sufficient redundancy shall be considered in the design such that no single component failure will shut down the system.

HVAC and ventilation systems shall be seismic braced/anchored. All design shall be in accordance with local and national seismic design requirements.

Evaporator coil coating shall be required if outside air is drawn from the exterior. Indirect waste from the HVAC system(s) shall be disposed per local and national plumbing codes. HVAC/ventilation design shall comply with all Applicable Laws. HVAC/Ventilation shall require interlock to the shelters fires alert system for shutdown. If explosion prevention or deflagration venting is required by the applicable safety codes and standards as a result of large-scale fire testing, activation of mechanical ventilation system activation shall require interlock to the shelter's flammable gas detection system.

4.15.3 Fire Protection

The Contractor shall provide fire protection system for the complete energy storage system including modification of existing site fire protection system to meet all applicable codes including the 2020 Edition of NFPA 855 "Standard for the Installation of Stationary Energy Storage Systems" and the latest approved revision of the applicable local fire protection codes.

Contractor shall comply with NFPA coordination, design, installation, commissioning, testing, training and startup requirements. This shall include all other requirements as outlined in this specification. Fire Protection system design shall include, but not be limited to, the following:

- Emergency vehicle access and fire hydrants per applicable local and national codes;
- Failure Modes and Effects Analysis or other approved Hazard Mitigation Analysis (HMA) in accordance with the applicable local fire protection codes and safety standards to defend and gain alignment for the system design with all key stakeholders before the design is finalized (e.g. risk mitigation for thermal runaway prevention);
- Enclosure design in accordance with NFPA requirements for location, separation, materials of construction, ventilation, smoke or flammable conditions detection, fire suppression, communications/alarms, explosion control, training, commissioning, permitting, and documentation as required by UL 9540 listed design and applicable local codes. Unless otherwise approved by Owner and the local fire code official, design shall include:
    - Smoke detection system in accordance with NFPA 72.
    - Off-gas detection.
    - Fire control and suppression with automatic sprinkler system per NFPA 13 or other approved automatic fire control and suppression systems or equivalent. based on reports issued as a result of large-scale fire testing.
    - Permanent source of water for fire protection. If water source is not available on site, water storage tank and all other necessary equipment shall be provided internal to the enclosure.
    - Explosion prevention system designed and installed per NFPA 69 or deflagration venting installed per NFPA 68.

- The fire alarm control panel shall provide supervised addressable relays for HVAC controls. The HVAC Engineer shall design and specify startup and testing services to support the interface with the Fire Protection System and ensure that the HVAC is controlled as designed. Alarms shall clearly annunciate location of detected condition within building or by individual enclosure.
- Startup and testing of the Fire Protection System will be provided by the fire protection contractor in accordance with NFPA requirements.
- Fire suppression chemicals shall be selected based on their effectiveness and also based on their long-term availability. Some common fire suppression chemicals such as Novec and FM200 are being phased out and these chemicals shall not be used.

Contractor will provide an Emergency Operations Plan that includes emergency procedures to be followed in case of potentially dangerous conditions, in addition to response conditions similar to a safety data sheet (SDS) that will address response safety concerns and extinguishment.

If lithium-ion batteries are proposed as the storage medium, the Contractor shall provide an optional price for a lithium-ion battery fault detector utilizing an off-gas sensing system that will detect off-gassing at the cell level. This system shall be integrated into the Contractor's control system and/or site controller.

4.16 Station DC System and Uninterruptible Power Supply

The Project shall be equipped with a Station DC system and/or a UPS to power essential functions in the event of a total failure of auxiliary supply systems(s) if required for orderly shutdown. The provided DC system/UPS shall comply with the applicable standards. The UPS must have a minimum of four hours of back-up power for power essential functions (including but not limited to EMS control power and communications rack power). All UPSs must have Modbus Ethernet connections for monitoring by the Owner's SCADA system. Protective relays must have a minimum of 8 hours of backup power.

4.17 Energy Storage System Design

The Contractor shall design, furnish and install an Energy Storage System (ESS) that meets all the requirements of the Agreement, including this Specification.

4.17.1 Cells and Modules (if applicable)

The energy storage shall consist of cells of proven technology designed for the type of service described herein. For the purposes of this Specification, proven technology shall be defined as cells that have been in successful commercial service in similar type applications for a period of time sufficient to establish a service life and maintenance history. Only cells that are commercially available or for which suitable (not necessarily identical) replacement cells (or modules or strings) can be supplied on short notice throughout the Project life will be allowed. Cells shall be listed to UL 1642 and manufacturer must provide UL certificate prior to shipment to Project Site.

The cells may be supplied as separate, individual units or as a group of cells combined into modules. Modules shall be listed to UL 1973, and UL 9540 and manufacturer must provide UL certificate prior to shipment to Site.

Cell construction and accessories (as applicable) shall be sealed to prevent electrolyte seepage. Post seals shall not transmit stresses between the cover or container and the posts. Cell terminals and interconnects shall have adequate current carrying capacity and shall be designed to withstand short-circuit forces and current generated by the energy storage. Safety features shall be designed into each cell in accordance with UL 1642, UL 1973, and UL 9540.

DC Contactors will disconnect the string from the circuit during high temperature conditions but will reconnect once the cell temperatures reach an acceptable range and other conditions are met allowing reconnection. Labeling of the cell (or modules) shall include manufacturer’s name, cell type, nameplate rating and date of manufacture, in fully legible characters or QR code. Contractor shall provide a list showing all the modules by their unique identification number along with their corresponding physical location within the project site. The unique identification numbers shall correspond to their identification within the Project so to provide easy location of all cells or modules.

The energy storage subsystem and its individual cells shall be designed to withstand seismic events as described herein. The batteries may consist of one or more parallel strings of cells.

DC wiring shall be sized per NEC Article 310 or based on UL standards and be appropriately braced for available fault currents. Protection shall include a DC breaker, fuse or other current-limiting device on the energy storage bus. This protection shall be coordinated with the PCS capabilities and energy storage string protection and shall consider transients and the Inductance/Resistance (L/R) ratio at the relevant areas of the DC system. The Project shall operate no higher than 1,500 Volts DC.

The Contractor shall provide information on the impact that weak or failed cells have on the life and performance of the entire string. The Contractor shall specify critical parameters, such as temperature variation limits between cells of a string. The Contractor shall provide a means of monitoring critical parameters to ensure the limits are being met.

Cells, wiring, and all DC electrical components shall be insulated for 2,000 Volts DC. The Contractor shall have overall responsibility for the safety of the electrical design and installation of the Project. The Project shall include a monitoring/alarm system and/or prescribed maintenance procedures to detect abnormal cell conditions and other conditions that may impair the ability of the Project to meet performance criteria.

The energy storage monitoring system shall be capable of balancing the voltages across cells automatically and independently without any input from the operator or the SEC. Cell monitoring system shall be specified so as to alert the proper personnel in a timely manner that an abnormal cell condition exists or may exist. Abnormal cell conditions shall include over- and under-cell voltage. Temperature is not expected to be monitored at the individual cell level.

The monitoring/alarm system will record data and notify the Owner on the number and general location of failed modules, to expedite maintenance and cell replacement. This data shall be stored in non-volatile memory. Such monitoring/alarm systems shall be integrated into the overall control system.

The Project shall include racks or shall consist of stackable modules of batteries. Aisle spaces shall be set to permit access for equipment needed for easy removal and replacement of failed modules. The lengths and widths of aisles shall conform to all applicable codes, facilitate access by maintenance personnel and be approved by Owner. As applicable, the racks shall provide sufficient clearance between tiers to facilitate required modules maintenance, including modules testing and inspection, and replacement.

Rack-mounted modules shall have all connections located on the front of the enclosure or module. Modules shall not be required to be removed from the racks during regular maintenance. All racks and metallic conductive members of stackable modules shall be solidly grounded. Racks shall be seismically designed based on the requirements of Section 1.4 and shall include means to restrain cell movement during seismic events. All design shall be in accordance with seismic design requirements as specified in Section 1.4 of this Specification.

4.18 Medium Voltage Switchgear

Metal-enclosed switchgear shall be designed, constructed and tested per IEEE C37.20.3. Metal-clad switchgear shall be designed, constructed and tested per IEEE C37.20.2. Design test results shall be provided to the Owner prior to shipment to the Site.

4.18.1 Field Tests

Contractor shall:

- High-potential test each breaker in accordance with IEEE C37.20.2, Table 1 and part 6.5. Apply test voltage to each pole of the breaker for one minute.
- Test and record contact resistance on each phase from bus to load terminal through a closed breaker.
- Record operation counter reading.
- Perform vacuum integrity test.

The MV switchgear lineup shall be rated to continuously carry nominal Project generation. The lineup shall contain power metering and voltage transformers, fused switches and circuit breakers as necessary to collect and interconnect full plant generation.

Switchgear shall include an auxiliary compartment containing all instrument transformers associated with the protective relays and a 120/240 Volt Control Power Transformer. The Control Power Transformer shall be fused and able to disconnect. The Control Power Transformer shall be sized to supply the expected continuous load, with approximately 20 percent margin for future load growth. The transformers shall be air-cooled, dry type, with a 150 °C rise. Alternatively, site DC backup power may be used.

Switchgear shall be provided with a metering section containing provisions for utility meters. Consistent with the Owner’s Electric Distribution System Interconnection Handbook, the metering section includes cable pull sections, bus bars for metering CT/PT insertion; disconnect switches, a metering panel, a meter socket(s), and accommodations for test switches/test blocks. A set of visible disconnect switches, or rack-able breaker, shall be placed directly on the line side of each metering section as well as a set of disconnect switches for the metering PTs (accessible by Owner personnel only) per the Owner's service requirements. In addition, a set of disconnect switches shall be placed on the load side of the meter or at the point of generator output. Disconnect switches and rack-out breakers must accommodate locking devices to allow the Owner to lock-out services or net-generation points when necessary.

Protective relaying, metering, and control parameters shall be in accordance with the Owner Electric Distribution System Interconnection Handbook and reviewed and approved by Owner prior to construction. All design shall be in accordance with seismic design requirements as specified in Section 1.4 of this Specification.

4.19 Inverter-Connected 3 Phase, Liquid-Filled or Dry-Type Pad-Mount Transformer

Transformer LV windings shall be per inverter manufacturer's recommendations. Percent impedance voltage shall be according to the inverter manufacturer's recommendation. Transformers shall be rated for continuous operation of the inverters.

Transformers shall be configured as grounded-wye on the side toward the POI. The winding configuration on the side toward the PCS is the Contractor's choice.

Liquid filled transformers shall be designed, constructed and tested in conformance with IEEE C57.12.00. Liquid filled transformers shall contain a UL-listed and Factory Mutual Global Approved less-flammable dielectric coolant meeting the requirements of NEC Section 450-23 and the requirements of the National Electrical Safety Code, Section 15. Transformer shall be suitable for indoor or outdoor use as applicable meeting the requirements of NFPA 855. Routine test results shall be provided to the Owner prior to shipment to the Site. All design shall be in accordance with seismic design requirements as specified in Section 1.4 of this Specification.

For transformers connected to the PCS, the Contractor must provide calculations to demonstrate that the appropriate H-factor or K-factor has been selected. A sample calculation is shown below:

h	Ih	$(Ih)^2$	h^2	$(Ih)^2h^2$
1	1	1	1	1
3	0.1000	0.0100	9	0.0900
5	0.1500	0.0225	25	0.5625
7	0.1000	0.0100	49	0.4900
9	0.1000	0.0100	81	0.8100
11	0.1400	0.0196	121	2.3716
13	0.2000	0.0400	169	6.7600
15	0.0200	0.0004	225	0.0900
17	0.0500	0.0025	289	0.7225
19	0.0075	0.0001	361	0.0203
21	0.0050	0.0000	441	0.0110
SUM		1.1151		12.9279 K FACTOR

4.19.1 Field Testing

- Verify nameplate data.
- Coordinate and perform instrument transformer tests on CTs with transformer assembly.
- Verify correct polarity of CTs.
- Winding Tests:
  - Transformer Turns Ratio (TTR) at all no-load taps.
  - Megger winding to ground.
  - Megger winding to winding.
  - Set HV taps at positions determined by Engineer.
- Check and measure equipment ground; ground shall not be more than one ohm.
- Check insulating fluid for clear or pale amber color and report any variance to the Owner. Other colors may indicate contamination from decomposition of insulation, foreign material, carbon, or other substances.
- Test oil samples from each transformer with standard AC test in accordance with ASTM D1816. Notify the Owner if breakdown voltage is less than 30 kV.
- Check liquid level in tanks, and in bushings of the liquid-filled type, and check nitrogen content in inert gas sealed oil preservation systems.
- Check that all valves are open between the transformer tank and cooling equipment.
- Check operation of cooling equipment and cooling controls before energizing transformer.
- Check calibration of pressure relief device, top oil temperature relay, and hot spot temperature relay.
- Pressure test the sudden pressure relay in accordance with the manufacturer's instructions to verify proper operation of device and electrical contacts.
- Alarm Sensor Testing: Induce the device to operate with proper input medium (heat, cooling, pressure, vacuum, voltage, current, etc.) and verify operation of the device at the correct input medium level by monitoring the output contacts with an ohmmeter.
- Annunciator Testing: Check each unit of annunciators by closing or opening the trouble contact and observing operation of control board.
- Check all annunciator lamps, bell cutoff, and reset operation.
- Test all gauges including level, temperature, and pressure gauges.

No Load taps labeled per IEEE Std C57.12.34. Full-capacity taps in high-voltage winding:

- Two 2.5% taps above rated voltage.
- Two 2.5% taps below rated voltage.
- Transformer compartments shall have provisions for padlocking.

- High-voltage compartment shall contain terminations for dead-break elbows, and provisions for entrance of multi-conductor high-voltage, insulated, shielded, power cable. Provide terminations with stress relief devices.
- Transformer shall be equipped with a load-break switch that is oil immersed in transformer tank. The handle shall be located on the exterior tank wall. The switch shall be operable without exposure to any live circuits.

Include accessories as follows:

- Dial-type thermometer with contacts for high-temperature warning and alarm levels
- Magnetic liquid level gauge with alarm contact for low level.
- Pressure/vacuum gauge with alarm contacts.

4.20 Dry Type Transformers

Dry type transformers shall be designed, constructed and tested in conformance with IEEE C57.12.01. Dry type transformers shall be ventilated dry-type cast coil, Class AA suitable for indoor or outdoor use as applicable. All designs shall be in accordance with seismic design requirements as specified in Section 1.4 of this Specification.

4.20.1 Field Testing

- Verify nameplate data.
- Winding tests:
  - Transformer Turns Ratio (TTR) at all taps.
  - Megger winding to winding.
  - Megger winding to ground.
- Check equipment ground to assure continuity of connections. Notify the Owner if ground is more than one ohm.
- Check electrical neutral of the transformer. This connection shall be a copper wire connection to the station ground grid.
- Check for proper operation of the winding temperature gauge and cooling fans.
- Set HV taps at positions determined by Engineer.
- Check connections for tightness; clean out dust and other foreign material.

No Load taps labeled per IEEE Std C57.12.34. Full-capacity taps in high-voltage winding:

- Two 2.5% taps above rated voltage.
- Two 2.5% taps below rated voltage.

4.21 Raceways

4.21.1 Conduit

- Contractor shall install all conduit, bends, accessories, fittings, junction boxes, mounting hardware, etc., to produce the complete system.
- Conduit shall be sized and installed in accordance with the NEC.
- In general areas, Electrical Metallic Tubing can be used for all feeders hidden from view above ceilings and in walls. Electrical Metallic Tubing fittings shall all be compression-type fittings. Set-screw fittings shall not be utilized.
- Flexible Metal Conduit or Liquid-tight Flexible Metal Conduit shall be used for connections to motors, transformers, machinery, lighting, and for other equipment subject to vibration.
- Rigid Metal Conduit or Intermediate Metal Conduit shall be used as allowed in the NEC.
- Plastic conduit, elbows, couplers and other fittings for underground application shall be Schedule 40 PVC, UL or ETL Listed. Fabrication, testing, and installation shall be per NEMA TC-2. Direct buried conductors will not be allowed. Each underground conduit package shall include at least one spare conduit for communications circuits.
- Reinforced Thermosetting Resin Conduit (Fiberglass RTRC) conduit, elbows, couplers and other fittings shall be UL or ETL Listed. Fabrication, testing, and installation shall be per NEMA TC-14. Direct buried conductors will not be allowed. Each underground conduit package shall include at least one spare conduit for communications circuits.
- Threaded or compression fittings shall be used with all raceway types. Set-screw fittings are not permitted.
- All conduits shall be sealed by Owner approved duct seal or foam.
- Any conduits intended to contain fiber optic cables will only use large radius factory sweeps, not 90-degree elbows.
- Conduits containing CT or PT conductors for Owner’s revenue metering may not use condulets.

4.21.2 Tray

- Tray shall be fabricated, tested, and installed per NEMA VE1, NEMA VE2, and the NEC.
- Aluminum: Straight section and fitting side rails and rungs shall be extruded from Aluminum Association Alloy 6063 and all fabricated parts shall be made from Aluminum Association Alloy 5052, in accordance with ASTM B221 and ANSI H35.1.
- Pre-galvanized Steel: Straight sections, fitting side rails, rungs, and covers shall be made from steel meeting the minimum mechanical properties and mill galvanized in accordance with ASTM A653 SS, Grade 33, coating designation G90.
- Hot-dip Galvanized Steel: Straight section and fitting side rails and rungs shall be made from steel meeting the minimum mechanical properties of ASTM A1011 SS, Grade 33 for 14 gauge and heavier, ASTM A1008, Grade 33, Type 2 for 16 gauge and lighter, and shall be

hot-dip galvanized after fabrication in accordance with ASTM A123. All hot-dip galvanized after fabrication cable trays and components must be returned to point of manufacture after coating for inspection and removal of all icicles and excess zinc to mitigate damage to cables and/or injury to installers.

- Hardware shall be zinc plated in accordance with ASTM B633, SC1. If aluminum cable tray is to be used outdoors, then hardware shall be Type 316 stainless in accordance with ASTM F593 and F-594.
- Any exterior tray shall include a cover.
- All design shall be in accordance with seismic design requirements as specified in Section 1.4 of this Specification.

4.22 Medium Voltage Cable

- Aluminum or Cooper cable shall be listed to UL 1072 and adhere to NEC requirements.
- Cable furnished shall be suitable for installation in underground ducts and conduits, trays, underground structures, and in outdoor applications of direct underground burial or for use in suitable supported aerial applications. Cable shall be rated for wet and dry locations.
- Insulation shall be thermosetting compound with minimum ratings for normal conductor temperatures of 90°C, 140°C for emergency operation condition, and 350°C for short circuit conditions.
- Cable shall be tested at the factory and reports delivered to the Owner prior to shipment. Once test results are provided to the Owner, it will have five business days to review testing reports. Contractor shall not ship cables until the Owner approves the test reports or the review period expires.

4.22.1 Field Tests

- Field high potential test in accordance with NEMA WC 74 (ICEA S-93-639), Table F-1, DC Test Voltages After Installation and NETA ATS, Table 100.6, Medium-Voltage Cables Acceptance Test Values, as follows:

		DC TEST VOLTAGE (KV)	
Rated Voltage (kV, Phase-Phase)	Conductor Size AWG or kcmil	100% Insulation	133% Insulation
2,001 – 5,000	8 – 1,000	28	28
2,001 – 5,000	1,001 – 3,000	28	36
5,001 – 8,000	6 – 1,000	36	44
5,001 – 8,000	1,001 – 3,000	36	44
8,001 – 15,000	2 – 1,000	56	64
8,001 – 15,000	1,001 – 3,000	56	64
15,001 – 25,000	1 – 3,000	80	96
25,001 – 28,000	1 – 3,000	84	100
28,001 – 35,000	1/0 – 3,000	100	124
35,001 – 46,000	4/0 – 3,000	132	172
46,001 – 69,000	4/0 – 3,000	N/A	195

- The initially applied DC voltage shall be not greater than 3.0 times the rated AC voltage of the cable.
- The duration of DC voltage test shall be 15 minutes.
- Do not test cables with an AC test set. Disconnect from all equipment during testing. Testing cable on the reel will not be acceptable. Perform tests after installation, but before final connection to equipment. Make high potential tests between each conductor and shield, or between conductor and armor with shield or armor grounded.

4.23 2.0 kV Cable

- Aluminum or Copper cable shall be listed to UL 44 and adhere to NEC requirements.
- Cable shall be rated for use in conduit, underground ducts, and cable tray.
- Insulation shall be thermosetting compound with minimum ratings for normal conductor temperatures of 90˚C.
- Field Tests
  - Megger insulation resistance testing is required prior to energization.

4.23.1 Field Tests

- All field tests shall be performed by a certified third-party testing company.
- In addition to the tests specified previously, the following tests shall be conducted:
  - LV breakers 100A and greater shall be trip tested.

4.24 Substations

All Project substation design and construction shall comply with M1-05-03 (Substation Design and Construction Specification) and M1-04-02 (General Transformer Specification).

4.25 Communication Facilities

All Project communications facilities shall comply with M1-05-04 (Communication, SCADA, and Metering Facilities).

5.0 APPENDIX A - APPLICABLE STANDARDS AND CODES

No.	Standards	Code
1	ANSI/IEEE C2	National Electric Safety Code
2	IEEE 519	IEEE Recommended Practices and Requirements for harmonic Control in Electrical Power Systems
3	IEEE 1815-2012	IEEE Standard for Electric Power Systems Communications— Distributed Network Protocol (DNP3)
4	IEEE 1547-2018	IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems
5	IEEE 1547.1	Standard Conformance Test Procedure for Equipment Interconnecting Distributed Resources with Electric Power Systems
6	IEEE 1547.2	Interconnecting Distributed Resources with Electric Power Systems
7	IEEE 1547.3	Guide for Monitoring, Information Exchange, and Control of Distributed Resources Interconnected with Electric Power Systems
8	ANSI Z535	Product Safety Signs and Labels
9	ANSI C57/IEEE	Transformer Standards, whenever applicable
10	ANSI C37/IEEE	Surge withstand capabilities, whenever applicable
11	UL 1642/IEC 62133	Applicable sections related to battery cell safety, where applicable
12	UL 1741	Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources
13	NFPA 704	Standard System for the Identification of the Hazards of Materials for Emergency Response
14	UL 1642	Standard for Lithium Batteries
15	UL 1778	Underwriters Laboratories' Standard for Uninterruptible Power Systems for up to 600 Volts AC
16	UL 1973	Standards for Batteries for Use in Light Electric Rail Applications and Stationary Applications
17	UL 9540/9540A	Standard for Energy Storage Systems and Equipment / Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems
18	Electric Tariff Rule 21	Generating Facility Interconnections
19	NISTIR 7628	Guidelines for Smart Grid Cyber Security
20	NEC	National Electric Code
21	NESC	National Electric Safety Code
22	ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
23	CAA	Clean Air Act and Amendments
24	CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
25	EPA	Environmental Protection Agency regulations
26	FAA	Federal Aviation Administration regulations

No.	Standards	Code
27	FERC	Federal Energy Regulatory Commission regulations
28	FPA	Federal Power Act
29	RCRA	Resource Conservation and Recovery Act
30	SDWA	Safe Drinking Water Act
31	SWDA	Solid Waste Disposal Act
32	TSCA	Toxic Substances Control Act
33	ADA	Americans with Disabilities Act
34	MBTA	Migratory Bird Treaty Act
35	CWA	Clean Water Act
36	ANSI	American National Standards Institute
37	IEEE	Institute of Electrical and Electronics Engineers
38	NEMA	National Electrical Manufacturers Association
39	ASTM	American Society for Testing and Materials
40	ASME	American Society of Mechanical Engineers
41	IEEE 1881	Standard Glossary of Stationary Battery Terminology
42	IEEE 519	Recommended Practice and Requirements for Harmonic Control in Electric Power Systems
43	IEEE 142	Recommended Practice for Grounding of Industrial and Commercial Power Systems
44	IEEE 242	Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
45	IEEE 2030.3	Standard Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications
46	EPRI 3002009313	Energy Storage Integration Council Energy Storage Test Manual 2016
47	IEEE 1881	Standard Glossary of Stationary Battery Terminology
48	Owner S-76	Below Grade Substation Standards
49	MESA	Open Standards for Energy Storage
50	NFPA 855	Standard for the Installation of Stationary Energy Storage Systems
51	OSSC	2014 Oregon Structural Specialty Code
52	International Building Code	2012 International Building Code
53	ACI-318	American Concrete Institute 318-11
54	AWS	American Welding Society D1.1 Structural Welding Code - Steel
55	OFC	2019 Oregon Fire Code
56	IEEE 2800	IEEE Standard for Interconnection and Interoperability of Inverter-Based Resources Interconnecting with Associated Transmission Electric Power Systems

6.0 APPENDIX B - CONCEPTUAL ONE-LINE DIAGRAM

To be submitted by Contractor at the time of bid submittal.

7.0 APPENDIX C - ENERGY STORAGE SYSTEM FACTORY ACCEPTANCE TESTING PROCEDURE

To be submitted by Contractor as an exhibit to the Agreement at the time of contract execution.

8.0 APPENDIX D - STATE MATRIX

		Standby	Run	Current Source Enable	Sync Request	Black Start Enable	Inverter Ready	Inverter Running	Island Ready	Synch Ready
1	Standby	1	0	0	0	0	1	0	0	0
2	Island	1	1	0	0	0	1	1	1	0
3	Synch request	1	1	0	1	0	1	1	1	1
4	Black Start	1	1	0	0	1	0	0	0	0

9.0 APPENDIX E - SCADA INTERFACE

The following is information of the data objects being used by the Owner for the purpose of controlling and monitoring storage systems via a communications gateway. Contractor will appropriately deploy or provide an interface which utilizes either DNP3 or Modbus TCP/IP protocol. This interface shall be a port that is integral to the Contractor's SEC or Ethernet switch. Achieving the correct communications protocol by use of a separate communications gateway is not allowed. Additionally, Contractor will implement and make available multiple points lists, including integration of the Owner's Points List as specified below.

Note the alarms list for each system has not been listed, as systems provide a multitude of alarms. In all cases, the complete set of all possible alarms must be conveyed via alarm word points at each level, System and Subsystems (Inverters and Energy Storage Banks Blocks, Modules or Cells). Each bit of a given word must be mapped to a single alarm (fault or warning). Multiple alarms words can be utilized at every level if the number of alarms exceed the number of bits available in a single alarm word.

It should be also noted that any other device capable of generating alarms within the energy storage system should have its alarms passed to the Owner's gateway via the same, single interface described in this section. Any resettable alarms, for any device capable of generating alarms, must be able to be reset via the same, single interface.

Contractor will provide a draft communications and tag name spreadsheet at the 30% design review. The spreadsheet will include an IP address for every addressable device in the project as well as all the Project tag names. Accommodation will be made for Owner addressable devices on the network and Owner's required tags. When the spreadsheet reaches the 90% review level, new tag names shall only be added to the bottom of the list.

Contractor's tag list shall comply with IEEE 1815-2012 and DNP Application Note AN2018-001 Version 2019-01-15.

10.0 APPENDIX F - SITE ACCEPTANCE TEST

To be submitted by Contractor as an exhibit to the Agreement at the time of contract execution.

11.0 APPENDIX G - APPROVED VENDORS AND SERVICE SUPPLIERS

This section provides a list of approved Suppliers for plant materials, equipment, and services. The Contractor may not deviate from this list prior to contract award but may do so after contract award only with prior written Owner approval.

In some categories, a Supplier has been identified as “Preferred” with an (*) in order to maintain the same Suppliers of equipment as PGE has utilized the Supplier for its generating fleet and has had favorable experiences.

The basis for the plant design should generally be the “Preferred” Suppliers in areas where common operating procedures, routine maintenance or spare parts can be affected.

In other areas, the Owner shall be notified and shall have the option to select an identified equipment “Preferred” Supplier via a Change Order if the “Preferred” Supplier is not the Contractor’s evaluated equipment bidder. The Owner would not expect to see a request for change order however unless there are significant cost differences from the “Preferred” Supplier.

Final major equipment supplier list is to be approved by Owner. If Contractor is considering the selection of a material, equipment supplier, or subcontractor that is not listed herein, Contractor shall request approval from Owner prior to executing any contract for the procurement of such material or with such equipment supplier or subcontractor.

- BESS Suppliers, Batteries (Cells)
  - BYD
  - CATL
  - LG Chem
  - Samsung
  - Panasonic
  - Tesla
- BESS Suppliers, Inverters
  - Power Electronics
  - SMA
  - Sungrow
  - Tesla
  - TMEIC
  - EPC
- Generator Circuit Breaker
  - *ABB
  - GE Grid Solutions

  - Mitsubishi
  - Siemens
  - HVB
- Generator Step-up Transformer (substation main power transformer)
  - ABB, Varennes, Canada shop
  - ABB, St. Louis, Missouri shop
  - ABB, Bad Honnef, Germany shop
  - ABB, South Boston, Virginia shop
  - HICO, ChangWon, South Korea shop
  - Hyundai, Montgomery, Alabama shop
  - Hyundai, Ulsan, South Korea shop
  - Smit, Nijimegen, The Netherlands shop
  - SPX Waukesha, Waukesha, Wisconsin shop
  - EFACEC, Arroteia, Portugal shop
  - Siemens, Guanajuato, Mexico shop
  - GE Prolec, Monterrey, Mexico shop
  - Shihlin, Taipei, Taiwan shop
- Ground Reference Transformers
  - ABB
  - Cooper Power Systems
  - GE
  - Virginia Transformer
- GSU Pad-mount Transformers
  - ABB
  - General Electric
  - Cooper Power Systems
  - Siemens
  - WEG
- Instrument Transformers
  - ABB
  - Trench Ltd
  - GE/Alstom
- Load Center Unit Substations

- ABB
- Eaton
- General Electric
- Powell Manufacturing
- Schneider Electric / Square D
- Siemens Power T&D

- LV Motor Control Centers
  - *Eaton
  - ABB
  - Allen Bradley
  - General Electric
  - Powell Manufacturing
  - Schneider Electric / Square D
  - Siemens Power T&D
- Medium Voltage Switchgear, Starters and Controllers
  - Powercon
  - Siemens Power T&D
  - ABB
  - Eaton
  - General Electric
  - Powell Manufacturing
  - Schneider Electric / Square D
- Protective Relays *
  - Schweitzer Engineering Laboratories (SEL)
  - * Final devices must be compatible with PGE standards and approved by PGE in advance of final design and start of construction
- Relay Panels
  - Electrical Power Products (EP2)
- Revenue Meters
  - SEL
  - Schneider Ion 8650
- SF6 Circuit Breakers (High Voltage and Medium Voltage)
  - Siemens
  - ABB

- Mitsubishi
- GE/Alstom
- Hitachi/HVB (Georgia)

- Single Mode Fiber Cable & Attachment Hardware
    - AFL
    - OFS
    - Preformed Line Products
    - Anixter
- Substation Capacitors
    - Cooper Power Systems
    - General Electric
- Substation Control Enclosure
    - Trachte
    - AZZ
    - Systems control
- Substation Disconnect Switches (115-230KV)
    - Pascor
    - Cleaveland Price
- Substation Distribution Metering
    - Novatech Bitronics M871 (SCADA distribution feeder metering)
    - Novatech Bitronics M650 (SCADA distribution transformer metering)
- Substation Human/Machine Interface
    - Schneider Electric
- Substation Remote Terminal Unit
    - Eaton Cooper Power System
- Substation SCADA Ethernet Switches and Port Servers
    - Siemens RuggedCom RSG2300 – Managed Layer 2 switch, Rack mount, 32 ports
    - Siemens RuggedCom RS900 – Managed Layer 2 switch, Rail mount, 9 ports
    - Siemens RuggedCom RX1500 – Managed Layer 2 & Layer 3 switch, Rack mount, maximum 24 ports
    - Siemens RuggedCom RS416 – Serial port server, Rack mount, 16 ports
- Substation SCADA Gateway
    - Eaton Cooper SMP SG4250
- Substation SCADA Input/Output Devices

  - Eaton Cooper Power Systems
- Transformer Bushings
  - PCORE
  - ABB
- Uninterruptible Power Supply System (UPS)
  - *Vertiv Chloride (formerly Emerson Network Power)
  - Ametek Solidstate Controls
  - CEG
  - Gutor/Schneider
- 48 VDC Battery & Charger
  - East Penn Manufacturing
  - C&D Technologies
  - Eltek/Valere
- 125 VDC Chargers
  - *SENS
  - *Vertiv Chloride (formerly Emerson Network Power)
  - Ametek Solid State Controls
  - Cyberex
  - Hindle Power
- 125 VDC Batteries
  - *GNB
  - BAE
  - Hoppecke
  - C&D Technologies

Appendix M1

Attachment 01

Exhibit 02

Engineering Documents, Drawings, and Other Deliverables

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

REQUEST FOR PROPOSAL

NO.	DATE	REVISION	BY	CHK'D	APPROVALS	
0	26Oct21	Issued for Implementation	1898 & Co.		JAL	Jared Lathrop
1	14Apr23	Update from 2021 version	1898 & Co.	PGE	CPA	Craig Armstrong

Table of Contents

1 M1-01-02-Engineering Documents, Drawings, and Other Deliverables

1.1 Submittals

Contractor shall supply all drawings, calculations and study reports, plans, specifications, and information to the Owner as part of the scope of Work. Documents and information shall include, but are not limited to, the deliverable list in M1-01-02-01 (Engineering Documents, Drawings, and Other Deliverables Table), in each case for the relevant technology (wind, solar, storage) as applicable. Items marked in the submittals table per the applicable technology (wind, solar, storage) shall be submitted for the Owner's review and approval prior to equipment purchase or construction.

Within 60 days of the Effective Date, Parties shall identify and mutually agree upon all OEM equipment submittals and specifications which will be submitted to the Owner and those that the Owner will review. Conformed to construction record drawings (as-builts) shall be provided for selected drawings marked as Level C.

Contractor shall organize a face to face or real time meeting with the Owner prior to Construction to review design documents.

As the project progresses through engineering and construction, the Contractor shall provide to the Owner the current revision of the drawings and documents according to the normal project communication distribution to be decided upon during project kickoff. These distributions shall be provided in electronic copy in native file format.

Upon completion of any drawing or document revision(s), Contractor shall submit the drawing(s) or document(s) within 2 days to the Owner.

1.2 Document Submittal Requirements

1.2.1 Drawings

Drawings requested by the technical specifications are to be sent as directed therein. Drawings associated with this Contract shall be in the English language and English system of units.

Each submitted drawing shall be unique and shall be clearly marked with the name of the Project, facility name, facility designation, specification title, specification number, project equipment or structure nomenclature, component identification numbers, Owner’s name, revision number, and revision history.

Final as-built drawings, including Contractor drawings and vendor drawings, shall be submitted in electronic format on electronic storage device. Each form of media shall be clearly labeled for content and date.

Contractor shall submit all drawings in AutoCAD (.dwg) version 2014 format including bound files, XREF files, 3D models (saved out to

Autodesk Plant 3D 2014 or approved equal), sheet drawing files, and Acrobat Adobe (.pdf) format. All color settings files (*.ctb), font files, block libraries, title blocks, and CAD Standards used on the Project shall follow M1-01-09 (PGE CAD and Numbering Standards). Exceptions shall be submitted to Owner in electronic format that is clearly labeled for content and date.

Two electronic files of all professional engineer (PE) stamped drawings approved for construction shall be submitted to PGE. One file shall be a scan of the PE-stamped and signed (approved) drawing original in (.pdf) format. The second file shall be an AutoCAD (.dwg) drawing file and shall include as-built updates.

Contractor shall create and maintain a master drawing list including, as a minimum, drawing number, revision letter/number, revision date, drawing title, Discipline, Document Status, Document type, Plant System, and cross-reference listing for associated vendor drawing numbers, and date submitted to PGE for review. See below for a list of preferred terms. Contractor shall provide to the Owner an initial copy of the master drawings list prior to issuance of any project drawings at the start of the project. The Master Drawing list will be updated and included with every drawing transmittal. Master drawing list must be compatible with Microsoft Excel. Final electronic master drawing list and program shall be submitted to Owner in electronic format and clearly labeled for content and date.

1.2.2 Design Masters

Contractor shall produce applicable drawings per Owner's standard Design Masters. In addition to standard design requirements, Design Masters dictate scope, size, symbology, nomenclature, and level of information required in a drawing. Contractor to request latest version of Design Masters from Owner prior to initiating any design. Microstation CAD files can be provided. The following apply:

High Voltage Lines

RAS

GSU Transformers

Unit Aux Transformers

Standby Transformer Metering and Protective Relaying One Lines

Three Lines

DC Metering and Protective Relaying Schematics

Panel Layout Drawings

Wiring Diagrams

Bill of Materials

Medium Voltage Switchgear and Generator Breaker Three Lines

DC Control Schematics

SCADA Block Diagram

SCADA DC Power Schematic

SCADA Panel Layout Drawings

SCADA Wiring Diagrams

SCADA Bill of Materials.

1.2.3 Other Requirements:

Submittals shall be accompanied by copies of native, electronic design files (e.g., AutoCAD .dwg file, PLS-CADD .bak file, electrical model files (PSS/E, EasyPower, ETAP, CYME), etc.), including for interim design transmittals (e.g., 30%, 90%, etc. as applicable) and As-Built Drawings.

All design submittals shall be provided in a common and consistent coordinate system. Such coordinate system shall be subject to Owner approval.

All design submittals (including product sheets, mix designs, verification procedures, installation procedures, testing procedures, etc.) shall be approved by the applicable engineer of record prior to submitting to Owner. An approval stamp from such engineer(s) of record shall be included on the submittal to indicate such approval.

Owner's review and approval of submittals will not relieve Contractor of responsibility for any deviation from the Requirements unless Contractor has in writing called Owner's attention to such deviation at the time of submission, and Owner has given written concurrence in and approval of the specific deviation. Approval by Owner shall not relieve Contractor from responsibility for errors or omissions in submittals.

As-Built Drawings: As-Built Drawings shall be issued as the next sequential revision from previous releases. The revision block shall state "As Built". All clouds, revision diamonds, and other interim control markings shall be removed, and all information listed as "later" or "hold" shall be completed. The As-Built Drawings shall include a final bill of materials, and native copies of all drawings and layouts. As-Built Drawings shall be created in the latest version of AutoCAD, or in the version of AutoCAD utilized by Owner, as applicable. As-Built Drawings shall comply with PGE Exhibit M1-01-09.

All engineering shall be performed under the supervision of and stamped by the engineer(s) of record, who shall be a registered professional engineer with a current license in the state where the Project is located. Such professional engineer(s) shall be registered in the applicable discipline for the drawings being signed and sealed.

1.3 Document Identification

Documents submitted by the Contractor for review shall be clear and legible and shall bear the Project Name in addition to the following:

1. Purchase order number
2. Project Facility – Unit Number – System number
3. Contractor's reference drawing number
4. Document revision status
5. Owner's documentation number (less submittal number)

This information shall be placed on the documents in or near the title block

Documents submitted shall be assigned an Owner documentation number assigned by the originator using the convention below. This number shall appear on the copy returned to the Contractor and shall be transferred by the Contractor to the Contractor's original, so that the document number will appear on subsequent submittals.

Correspondence including emails shall contain the Project Facility – Unit Number – System number, specification number, and equipment identification number.

All correspondence between Owner and Contractor shall be sequentially numbered as follows and provided in the subject line of emails:

AAA-BBB-SSSS-YYYY.X

Where:

AAA denotes the company originating the correspondence.

BBB denotes the company receiving the correspondence.

SSSS denotes the specification number

YYYY denotes the correspondence sequential number

X denotes the revision number of the correspondence beginning with zero.

Resubmittals shall bear the original submittal number and append a number sequentially as follows.

AAA-BBB-SSSS-YYYY.1

AAA-BBB-SSSS-YYYY.2

etc.

The Project Documentation Coordinator ([GPDC@PGN.com] for Owner; [ ] for Contractor) is responsible for assigning the correspondence number and maintaining their respective company transmittal log.

All correspondence shall be distributed electronically.

1.4 Document Review and Approval

The Contractor and Owner shall participate in 30%, 60%, 90%, and Issued for Construction (IFC) design and model reviews for each engineering package / discipline.

Design level	Description
30% Design	Most, if not all, of the design submittals may be conceptual in nature, without having all exact details defined. 30% design documents shall be provided as a single comprehensive submittal. To the extent possible, all PDFs shall be combined into a single file. For example, 30% design documents level of detail shall include (at minimum): • General arrangement drawings • Single line drawings • Cable and road layouts • Equipment specifications and data sheets Refer to M1-01-02-01 (Engineering Documents, Drawings, and Other Deliverables Table) for specific details.

60% Design	Design documents intended to represent a reasonably complete design package. Many of the design submittals may be conceptual in nature, without having all exact details defined. 60% design documents shall be provided as a single comprehensive submittal. To the extent possible, all PDFs shall be combined into a single file. For example, 60% design documents level of detail shall include (at minimum): • Design Basis: • Design criteria for each engineering discipline • Contractor's equipment and system designation methods • List of systems and system designations Electrical Package: Schematics and single line drawings detailing: collection system circuits, ac collection system, auxiliary and backup power, MET stations, SCADA/DAS and communications systems, grounding design Wiring details including: specifications for all conductor types, conduit, protective devices and relays; ampacity calculations for all conductors; voltage drop calculations for all conductor runs; wiring details, minimum bend radii, conductor termination details, conduit fittings, etc. Equipment arrangement including conduit entry Supporting documentation for all components including: specification of all requirements for all components, manufacturer's datasheets, installation manuals, operations and maintenance manuals Civil/Structural Package: Calculations in accordance with Specifications • Geotechnical and Hydrology Reports • Structural inspection results/reports • Detailed Site layouts with elevation and topographic detail depicting mounting configurations for all equipment, grading plans, etc. • Foundation designs • Corrosion analysis Refer M1-01-02-01 (Engineering Documents, Drawings, and Other Deliverables Table) for specific details.

90% Design	Design documents intended to represent a nearly complete design package for final approvals prior to being issued for permit approval. The 90% design documents shall be provided as a single comprehensive submittal. For example, 90% design documents level of detail shall include (at minimum): • An updated version of the 60% design documents with revisions and additional detail where applicable. • Shall include equipment ratings for all power systems equipment, bus Work, enclosures, protective devices, etc. • Include all detailed information required to obtain all necessary construction permits from the AHJ • Commissioning Plan • Acceptance Test Plan • Final Energy Estimate Refer to M1-01-02-01 (Engineering Documents, Drawings, and Other Deliverables Table) for specific details.
IFC Design	Design documents intended to provide all required information for Subcontractors to construct the Project. IFC design documents shall be provided as a single comprehensive submittal. IFC design documents shall include, at minimum, complete and fully detailed submittals (all applicable drawings and calculations) for the following: • An updated version of the 90% design documents with revisions and additional detail where applicable. • Shall include all completed test results such as pile uplift and lateral resistance testing • Shall address any responses/comments from the AHJ Refer to M1-01-02-01 (Engineering Documents, Drawings, and Other Deliverables Table) for specific details.
As-Built (AB) Design Documents	Design documents intended to reflect design changes after the release of the IFC design documents and to document the design of the as-constructed facility. All changes from the IFC documents shall be approved by Owner. Refer to M1-01-02-01 (Engineering Documents, Drawings, and Other Deliverables Table) for specific details.

Where drawings or other documents are required, these documents shall be submitted for review in accordance with the Contractor's drawing submittal schedule. Drawings, specifications, and performance data submitted will be reviewed for adherence to the specification, suitability of design, equipment selection, conformance to design criteria, interfacing data, and for general information regarding plant operating characteristics. They shall include erection diagrams and other details, such as interface connections. Identification numbers shall be used to identify items on the documents. The sequence of submission of documents shall be such that information is available for an effective review of each document when it is received. Information on drawings shall be checked by the Contractor for accuracy before submission for review.

Owner will update the Master Document List indicating the documents have been reviewed and will email the transmittal to Contractor.

All documents and drawings submitted by Contractor for the first cycle will be reviewed by Owner and returned with comments within 20 Business Days after receipt of the documents or as agreed to between Owner and Contractor. For subsequent review cycles, a 15 Business Day cycle will be followed or as agreed to between Owner and Contractor.

Contractor documents will be considered received after documents have been posted and Owner has received email notification of the posting.

Contractor may request, in writing, expedited review for specific documents and drawings. All requests will be considered.

1.4.1 Documents / Drawings

Documents, including drawings and electronic models, submitted for review shall be provided in the document's original (native) format with another copy in Adobe Acrobat (.pdf) format. A separate file shall be provided for each unique document number. Multiple sheets with one unique document number can be submitted as one file.

All revisions shall be noted in redline format, where applicable. All drawing revisions shall be clouded.

1.4.2 Status Level Convention

Upon completion of a review, the reviewer will rename the document by appending one of four Status Levels at the end of the document file name. The status level assignments shall be as follows:

S1 = No Exception Taken. Contractor May Proceed with Fabrication or Construction

S2 = Revise as Noted and Resubmit. Contractor May Proceed Based on Making Revisions Noted.

S3 = Does Not Meet Specification Requirements. Revise and Resubmit. Hold Fabrication.

S4 = For Information Only.

Status Level S1: Documents and drawings that receive status level S1 are approved.

Status Level S2 and S3: Documents and drawings that receive status level S2 or S3 shall be resubmitted, with comments incorporated in the next revision. Documents and drawings resubmitted for review shall clearly show changes made to them from previous revisions. All changes on drawings shall be clearly designated with revision clouds or shall include a revision list on the drawings. Revision clouds from previous revisions shall be removed. Changes on other documents shall be circled or a separate list of changes to the documents shall be provided. If a separate list of changes to the documents is provided it shall be named as the original document with "_COMMENTS" appended to the end of the file name. Any comments not incorporated must be noted and explanation given, in writing, for the exclusion.

1.4.3 File Naming Convention

Reviewed documents returned to Contractor will utilize the Contractor assigned file name, but be modified to indicate comments were appended as follows:

For Documents:

Return Document File Name:

Supplier File Name_Rev_PGE_S#.pdf

For Drawings:

Supplier Drawing #_Sheet_Rev_PGE_S#.pdf

1.4.4 Resubmittal Naming Convention

Resubmittals shall bear the original submittal number and append a number sequentially. Following initial submittal of a document or drawing by Contractor, that document or drawing shall not be resubmitted until Owner comments have been received and incorporated by Contractor.

1.5 Document Transmittals

All correspondence that transmits data, documents, drawings and other information that is considered a contract deliverable (or affects the design, construction, commissioning or operation of the project), is to be transmitted with a transmittal letter. An email with transmittal number in subject line and transmittal letter attached shall be issued to alert Owner that documents/drawings were submitted. Informal correspondence can be transmitted via email or other means and will not require a transmittal number.

Document transmittals shall be in accordance with a specified project schedule.

Submittals shall be in accordance with the following:

- Prints shall be sharp, clear, and suitable for direct reading. The prints shall be black line reproducible on bond paper. Scanned submittals are not permitted.
- Hardcopy documents shall be folded, collated sets mailed flat in a regular mailing envelope. Electronic formats of documents shall be submitted on CD, DVD or electronic storage device (as appropriate) and shall be adequately protected to prevent damage during shipment.
- Drawing or engineering databases shall be included in the document transmittals with programs to access and maintain the information and must be compatible with Microsoft Excel.

1.5.1 Spare Parts List

The vendor shall provide a recommended Spare Parts list for regular equipment maintenance. The Spare Parts list shall be submitted in Microsoft Excel spreadsheet format.

1. Entries into the electronic parts list shall conform to the following:

   Description using the Noun, Modifier, Characteristic 1, Characteristic N, Standards Requirements:

2. Example description of an existing item in PGE's for – 36 IN 5/8 double arming bolt

   BOLT, DOUBLE ARMING, 5/8 IN X 36 IN, SQUARE HEAD, WITH 4 SQUARE NUTS, HOT DIP GALVANIZED PER ASTM A153, MADE IN ACCORDANCE WITH ANSI C135.1, PER ASTM A36, 12,400LB MINIMUM TENSILE STRENGTH

Description Element	Identify by answering the question:	Descriptor	Abbreviation Spelled out
Noun	What is it?	BOLT,	
Modifier	What kind?	DOUBLE ARMING,	
Dimensions	What size?	5/8 IN X 36 IN	
Characteristic	What is specific about this item?	SQUARE HEAD	
Characteristic	What is specific about this item?	WITH 4 SQUARE NUTS,	This is more of a requirement
Standard Requirements	Standard to adhere to?	HOT DIP GALVANIZED PER ASTM A153,	Specific Standard
Standard Requirements	Standard to adhere to?	MADE IN ACCORDANCE WITH ANSI C135.1,	Specific Standard
Standard Requirements	Standard to adhere to?	PER ASTM A36,	Specific Standard
Characteristic	What is specific about this item?	MIN TENSILE STRENGTH OF 12.400 LBS	This is more of a requirement

A. Dimensions Descriptors

Dimensions shall be spelled out to avoid confusion for the ordering party, the vendor, or Owner. Standard dimension descriptors should be adopted as follows:

Abbreviation	Description
DIA	Diameter
L	Long
W	Width, wide
D	Deep, depth
IN	Inches
FT	Feet
TPI	Thread per inch
TPM	Thread per millimeter

Universally accepted numeric descriptors of dimensions are to be used also. For example: Bolt, 1-1/2 IN-18x36 IN L

- 1-1/2 IN = Diameter
- 18 = Threads per inch
- 36 = Length

1.5.2 Standards Requirements Reference

Requirements based on particular standards shall be included in the following format:

Standard Abbreviated	Specific Standard Number
ASTM	A153
ANSI	C135.1
ASTM	A36

1.5.3 Special Characters

Information NOT to be Included in the Item Description:

Manufacturer's Name

There are places in PGE Owner PeopleSoft and Maximo software systems that are designated to keep this information.

Manufacturer's Model Number

There are places in PGE Owner PeopleSoft and Maximo software systems that are designated to keep this information.

Vendor's Name

Vendor's Catalog Number

Slang terms to describe items

Terms used in the trades shall not be used as item descriptors unless those terms are universally used by all manufacturers and throughout the industry.

Example: bell insulator is a lineman's term for a suspension insulator or dead end insulator. Manufacturers recognize this item as suspension insulator, not as bell insulator.

1.5.4 Use of Special Characters in Descriptions

Item Descriptions may contain any of the following characters:

Description	Character
Comma	,
Period	.
Hyphen	-

Item Descriptions must not contain any of the following special characters as they interfere with the Maximo to PeopleSoft interface.

Description	Character	Description	Character
Quotation Mark	“	Dollar Sign	$
Ampersand	&	Percentage	%
Apostrophe	‘	Asterisk	*
Less Than	<	Pound Sign	#
Greater Than	>	Exclamation Point	!
Question Mark	?	At Sign	@
Equal	=	Caret	^
Plus	+	Backslash	\
Underscore	_	Square Brackets	[ ]
Vertical Bar	|	Round Brackets	( )
Grave Accent	`	Curly Brackets	{ }
Tilde	~		

1.5.5 Instruction Manual

The Contractor shall furnish draft and final instruction manuals for the unloading, storage, installation, operation, and maintenance of the equipment. The manuals shall be delivered as specified in the Contract. The electronic versions of the manuals shall be word searchable PDF format, fully indexed and shall not be protected. The index shall link to the pages referenced in the index and the bookmarks shall coincide with the required tabs in the paper form.

1.5.6 Content

Manuals shall include the table of contents and index tabs (if multiple volumes are required, a table of contents listing materials included in each volume shall be supplied for each volume) specific to the furnished equipment. All pages shall be sequentially numbered.

1.5.7 Design

Description of the equipment and systems including accessory components, including nameplate ratings, illustrations showing elevations, cross section, and all details of the equipment with all parts named, and numbered.

When multiple model numbers are shown on the drawings, the equipment supplied for the project shall be clearly identified.

Specifications, test data, and all performance curves specified in the technical specifications.

- Outline drawing - final. Assembly drawings - final.
- All fluid systems schematics and piping diagrams. Electrical wiring diagrams.
- Motor Information Sheets.
- Electric Actuator Information Sheets.
- Control Panel Arrangements, including interior equipment arrangements identifying the individual components.
- Program, software, and firmware configuration, modeling, editing, and troubleshooting guides.

1.5.8 Installation

- Instructions for receiving, inspection, storage, and handling of equipment prior to installation.
- Installation instructions including step-by-step alignment and calibration procedures.
- Online and offline inspection procedures.
- Lists of trips and alarms, complete with set points.
- Calibration Data Sheet for each adjustable instrument included in the scope of supply.
- List of acceptable lubricants, insulating fluids, flushing fluids, hydraulic fluids, and fluid additives.

1.5.9 Operation

Complete and detailed operating instructions, including safety precautions, startup procedures, shutdown procedures, normal operation procedures, non-standard event procedures, and freeze protection requirements and philosophy of operation. Operating procedures and instructions shall provide the operator with information when and how to operate the equipment, including precautions, limitations and set points. Procedures listed in step-by-step sequence shall include preoperational checkout, startup, normal, remote, or emergency modes of operation, and stopping or shutting down part or all of the subject equipment. Troubleshooting charts and tables shall be used to list likely evidence of malfunction and what could be responsible. The effect of loss of normal power and effect of electricity supply frequency drop shall be addressed.

1.5.10 Maintenance

Detailed minor and major maintenance instructions, including description, maintenance checklist, step-by-step instructions for replacing the major components, use of special tools furnished, including but not limited to the following:

- Preventive Maintenance Schedule for all equipment with servicing procedures including instructions for dismantling and/or replacing components and routine electrical and mechanical procedures, tests, and checks for cleaning, lubricating and otherwise caring for equipment. These procedures shall include calibration and maintenance of interlocks and other safety features. The Preventive Maintenance Schedule shall be provided in an MS Excel® spreadsheet (or another consolidated database, if approved).

Step-by-step procedures for all anticipated equipment repairs.

Troubleshooting guide.

Illustrated parts breakdown including parts list including American Society for Testing and Materials (ASTM) designation (if applicable), and a list of recommended spare parts. Complete replacement parts list shall include manufacturers' part number for ordering, description, the quantity used, and the applicable item number, and drawing references.

- Recommended six (6) month layup procedure.
- List of maintenance tools furnished with the equipment.
- Safety provisions.
- Torque values for critical bolts.
- Field disassembly and assembly.
- Field overhaul of specific components.
- Tube plugging instructions including plug dimensions and recommended material.
- Overhaul instructions.
- Control system troubleshooting instructions.

- Lubrication instructions including system flushing.

The above listed requirements are the minimum requirements; however, requirements that are clearly not applicable to the equipment may be deleted with Owner's approval. Additional information that is necessary for proper operation and care of the equipment shall also be included.

The electronic versions of the O&M manuals shall be word searchable PDF format, fully indexed and shall not be protected. The index shall link to the pages referenced in the index and the bookmarks shall coincide with the required tabs in the paper form. Manuals exceeding 100 MG file size will be broken into smaller parts and labeled accordingly (e.g. XXXXXX_Manual_Part_1_of_X.PDF)

The descriptions shall not be general, applicable to any type and size of Contractor's equipment, but shall be specific with (whenever possible) references to drawings submitted by Contractor.

Manuals which contain information on multiple manufacturer models shall have the model used at Project highlighted.

1.5.11 Equipment Storage

The Contractor shall furnish complete and accurate storage records for any equipment, materials, or other Work that was previously produced, manufactured, constructed, or otherwise produced and that will be incorporated into the Project. For the avoidance of doubt, this shall include any transformers, wind turbines, or other equipment that was previously manufactured for tax qualification purposes (e.g., PTC). Storage documentation to be provided shall include visual inspection and testing records.

1.6 Project Workbook

At the conclusion of the project and prior to final completion (as defined for the applicable Project type – e.g., Wind Plant Final Completion or Solar Plant Final Completion), the Contractor shall provide the Project Workbook listing the Project documentation as specified below.

Potential terms to be used in Project Workbook drop-down menus:

Document Types:

- Bid Document
- Budget
- Calculation
- Certificate

- Collection System
- Construction Work Package
- Contract
- Correspondence
- Design Basis
- Drawing
- Easement
- Estimate
- GIS
- Historical Document
- Incident Reports
- Inspection
- Invoice
- Job Books
- License
- Manual
- Meeting
- Model
- Permit
- Photograph
- Plant Systems
- Presentation
- Plan/Procedure
- Proposal
- Purchase Order
- Regulatory
- Report
- RFI

- RFP
- Schedule
- Schematic
- Site Certificate
- Specification
- Submittal
- Transmittal
- Vendor Information
- Video
- Welding

Disciplines:

- Architectural
- Geotechnical
- Civil
- Communication
- Electrical
- Instrumentation & Control
- Mechanical
- Project Management
- Structural
- General
- Environmental
- HVAC
- Plumbing
- Fire Protection

Document Status

- 30%, 60%, and 90% design package
- As-Built

- Final Project Document
- Issued For Approval
- Issued For Construction
- Issued For Contract
- Issued For Information
- Issued for Record
- Issued For Review
- Mark-Up
- Redline
- S1 - No Exception taken. Proceed in accordance with Specification.
- S2 - Minor Comments, Revise and Return, Proceed with Construction, or fabrication.
- S3 - Major Comments, Revise and Return, DO NOT proceed with construction or fabrication.
- S4 - For Information Only
- Superseded

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Owner Approval: Must be submitted for the Owner's review and approval prior to equipment purchase or construction

Category	Deliverable:	Description:	Level A	Level B	Level C	Owner Approval	Owner Proposed Schedule	Contractor Proposed Schedule
Certification	3rd party structural design certificate	Third-party Registered Professional Engineer's Certificate confirming the suitability of all foundation(s) and that they are in accordance with the As-built drawings.			X			
Certification	Acceptance certificates	All completed Acceptance Certificates for Works prior to Substantial Completion milestone			X	X		
Certification	Capacity and Availability test report	Upon satisfactory completion or upon failure of the Capacity and Availability Test, as the case may be, the Contractor will issue an Acceptance Test Certificate to that effect.			X	X		
Certification	Electrical safety certficates	Electrical Safety Certificates for all electrical works to Applicable Laws, Regulations and Standards		X		X	Prior to energization	
Certification	Electrical system certificates of compliance	All electrical certificates of compliance			X			
Certification	Factory acceptance test reports	Copies of test certificates for all routine factory tests applied to all major items included in the electrical scope of Work, including, but not limited to, switchgear, power transformers, instrument transformers, protection relays and revenue metering systems.		X			8 weeks prior to start of relevant site work	
Certification	Factory acceptance test reports for electrical components	FAT certificates to be provided by Contractor shall include, but not necessarily be limited to, the following components: • Transformers, including: o Substation main power MV/HV transformer/s o Auxiliary MV/LV transformer/s o PCS/Inverter skid MV/LV transformers • Instrument transformers (i.e. CTs, VTs) • HV and MV switchgear and switchboards • LV distribution boards (AC and DC) • Cabling (HV, MV, LV and fiber optic) • HV and MV surge arrestors • Protection relays • Metering systems (revenue, check and power quality) • UPS systems • Switchroom batteries and chargers		X			Prior to delivery to Site	
Certification	Performance test report	Report summarizing test as specified. Upon satisfactory completion or upon failure of the Performance Test, theContractor will issue an Acceptance Test Certificate to that effect.			X	X		
Certification	Permanent on-site buildings	Permanent building designs shall be independently checked and approved by a certified structural engineer		X			6 weeks prior to building work	
Certification	Power Circle Test Report and Certificate	Upon satisfactory completion or upon failure of the Power Circle Test, as the case may be, the Consultant shall issue to Owner a report and a Performance Test Certificate to that effect.			X			
Certification	Protection settings signoff	Written endorsement by the interconnection provider in respect of all protection settings of the Project		X			Prior to Plant energization	
Certification	Reinforcement specifications and testing certificates	Certificates confirming manufacturers and processors of steel reinforcement hold a valid certificate of approval.		X			6 weeks prior to start of relevant work	
Certification	SCADA system warranty and results	Documentary evidence that the SCADA system is sufficient for recording and analysis of the data for the warranty tests; and confirmation and detailed report of how the SCADA system stores data and provides values to enable availability calculations.		X			6 weeks prior to start of relevant work	
Design	Civil works	30% Design including the following: • Buildings and structures		X		X	3 months after Agreement execution	

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Category	Deliverable:	Description:	Level A	Level B	Level C	Owner Approval	Owner Proposed Schedule	Contractor Proposed Schedule
		• Roads • Site drainage • Earthwork and compaction • HV/MV substation foundation/footings • Site landscaping • Site restoration/reclamation						
Design	Civil works	60% Design: An updated version of 30% Design with revisions and additional detail where applicable: • Detailed foundation design drawings required. • ALTA survey map		X		X		
Design	Civil works	90% Design: An updated version of 60% Design with revisions and additional detail where applicable		X		X	6 weeks prior to start of relevant work	
Design	Civil works	IFC Design: An updated version of 90% Design with revisions and additional detail where applicable		X		X		
Design	Civil works	As-built Design: Design changes after the release of the IFC Design Documents and to document the design of the as-consctucted facility.			X			
Design	Site electrical single-line system	30% Design including the following: • Energy storage system SLD, showing connection to PCS, step-up or isolation MV/LV transformers, all junction boxes, ground reference transformers (if applicable) and battery banks or blocks; protection SLD to be incorporated or provided separately • Earthing drawings		X		X	3 months after Agreement execution	
Design	Site electrical single-line system	60% Design: An updated version of 30% Design with revisions and additional detail where applicable.		X		X		
Design	Site electrical single-line system	90% Design: An updated version of 60% Design with revisions and additional detail where applicable		X		X	6 weeks prior to start of relevant work	
Design	Site electrical single-line system	IFC Design: An updated version of 90% Design with revisions and additional detail where applicable		X		X		
Design	Site electrical single-line system	As-built Design: Design changes after the release of the IFC Design Documents and to document the design of the as-consctucted facility including the following: • MV Protection Schematics • MV CB Control Schematics • LV Air CB Schematics • UPS Schematic • DC Circuit Schematic • Distribution Board schedules • Cable schedules (HV, MV, LV and Comms) • As-built MV Switchroom GA drawings, including MV and LV switchboards, protection panels, SCADA, battery / UPS, chargers, etc.			X			
Design	Fire Protection System documentations and drawings	Including as a minimum: • Fire Risk Evaluation/Fire Protection Design Basis Document		X		X	3 months after Agreement execution	

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Category	Deliverable:	Description:	Level A	Level B	Level C	Owner Approval	Owner Proposed Schedule	Contractor Proposed Schedule
		• Complete and detailed design drawings for each system. Drawings shall clearly indicate all wiring and equipment that is supplied or installed by Contractor. Drawing shall call out any design and material requirements (manufacture and code/standard). Contractor is responsible for reviewing materials and designs as part of the overall fire protection system, to ensure compliance with codes, standards and manufacturers' requirements. • Site fire protection plan drawings • Hydraulic calculations • Room integrity test results for clean agent suppression systems • Detailed control panel drawings • Detailed communication drawings						
Design	Fire Protection System documentations and drawings, as builts	Including as a minimum: • Operation and Maintenance manuals shall be provided. • Complete all required documentation and obtain necessary inspection required for the fire protection systems to be operated. Signed and filled out test forms shall be provided for each system provided. • As built drawings			X	X		
Design	Permanent on-site buildings	30% Design including but not limited to the following: • Layout • Elevation drawings • Structural • Architectural • Fire rating • Hold down	X			X	Agreement close	
Design	Permanent on-site buildings	60% Design: An updated version of 30% Design with revisions and additional detail where applicable. Detailed foundation design drawings required.		X		X		
Design	Permanent on-site buildings	90% Design: An updated version of 60% Design with revisions and additional detail where applicable		X		X	6 weeks prior to start of relevant work	
Design	Permanent on-site buildings	IFC Design: An updated version of 90% Design with revisions and additional detail where applicable		X		X		
Design	Permanent on-site buildings	As-built Design: Design changes after the release of the IFC Design Documents and to document the design of the as-consctucted facility.			X			
Design	Pre-engineered metal buildings (if applicable)	Including, but not limited to: • Detailed shop and erection drawings and product data • Foundation loads, anchor bolt setting diagrams, and details of required anchorage to concrete foundations • All calculations used in the development of building and anchor bolt design and of fabrication drawings		X		X	1 week after Agreement execution	
Design	Battery and PCS block design drawings	30% Design: Includes the general arrangement drawings of the following: • Battery blocks, including racks and modules as appropriate • Inverter Blocks • PCS		X			3 months after Agreement execution	

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Category	Deliverable:	Description:	Level A	Level B	Level C	Owner Approval	Owner Proposed Schedule	Contractor Proposed Schedule
		• Permanent and temporary buildings						
Design	Battery and PCS block design drawings	60% Design: An updated version of 30% Design with revisions and additional detail where applicable.		X		X		
Design	Battery and PCS block design drawings	90% Design: An updated version of 60% Design with revisions and additional detail where applicable		X		X	6 weeks prior to start of relevant work	
Design	Battery and PCS block design drawings	IFC Design: An updated version of 90% Design with revisions and additional detail where applicable		X		X		
Design	Battery and PCS block design drawings	As-built Design: Design changes after the release of the IFC Design Documents and to document the design of the as-consctucted facility.			X			
Design	Substation	30% Design including the following (as applicable): • Substation general arrangement drawing • Main power transformer(s) • Protection equipment and switchgear specifications • LV systemsincluding battery and UPS capacities/back-up time • Revenue and power quality meter specifications • Single line diagram (SLD) of substation, including main power transformer, reactive power compensation resources; protection SLD to be incorporated or provided separately		X		X	3 months after Agreement execution	
Design	Substation	60% Design including the following: • An updated version of 30% Design with revisions and additional detail where applicable • Submittals as required in Appendix M1 Attachment 05 Exhibit 03 – Substation Design and Construction Specification.		X		X		
Design	Substation	90% Design: An updated version of 60% Design with revisions and additional detail where applicable		X		X	6 weeks prior to start of relevant work	
Design	Substation	IFC Design: An updated version of 90% Design with revisions and additional detail where applicable		X		X		
Design	Substation	As-built Design: Design changes after the release of the IFC Design Documents and to document the design of the as-consctucted facility.			X			
Design	SCADA and communications network	30% Design including the following: • Information on the communications system, including specifications and drawings • Information on the SCADA system, including specifications and drawings • Fiber optic network drawings • Fiber optic splicing drawings, fiber optic distribution panel drawings • Complete list of all the data points and operational parameters applicable to the Contractor's proposed SCADA system. • Documentation describing how the availability and performance is calculated, stored and analysed in the SCADA system.		X		X	3 months after Agreement execution	
Design	SCADA and communications network	60% Design including the following (if applicable): • An updated version of 30% Design with revisions and additional detail where applicable • I/O connections drawings • Network used to communicate (transmission medium, network topology, communication protocols and fault tolerance)		X		X		

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Category	Deliverable:	Description:	Level A	Level B	Level C	Owner Approval	Owner Proposed Schedule	Contractor Proposed Schedule
		• Interfaces • Network layout • Point addressing scheme • Grounding requirements • Redundancy and UPS • Sensor locations and sensor orientations • Remote access • Viewing and display • Data collection and storage • Control • Reporting • Software and licenses • Comprehensive user manual explaining the operation and use of all the functions • Hardware manuals for all hardware and computers systems • Documentation including manuals, quality control, installation, commissioning and testing procedures						
Design	SCADA and communications network	90% Design: An updated version of 60% Design with revisions and additional detail where applicable		X		X	6 weeks prior to start of relevant work	
Design	SCADA and communications network	IFC Design: An updated version of 90% Design with revisions and additional detail where applicable		X		X		
Design	SCADA and communications network	As-built Design: Design changes after the release of the IFC Design Documents and to document the design of the as-consctucted facility including the following: • Detailed architecture, interfacing and component product identification • Network Data Communication, detailed wiring diagram • Fiber optic network • Interfacing • Power supply – SCADA distribution board SLD			X			
Design	Site layout/plans	Proposed Preliminary Layout including (as applicable): • Battery and PCS layouts • Landowner boundaries • Public roads • Access roads • Cable routes • Laydown areas • Substation • Transmission line • Borrow pits • Permanent and temporary buildings	X			X	Agreement close	
Design	Site layout/plans	30% Design including the following (as applicable): • An updated version of Preliminary Layout with revisions and additional detail where applicable • Junction boxes • Foundations/footings • Drainage and erosion control features • Spares, parts, tools and permanent storage • Temporary utilities, and		X		X	3 months after Agreement execution	

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Category	Deliverable:	Description:	Level A	Level B	Level C	Owner Approval	Owner Proposed Schedule	Contractor Proposed Schedule
		• Fencing, gate, signage and label details						
Design	Site layout/plans	60% Design: An updated version of 30% Design with revisions and additional detail where applicable		X		X		
Design	Site layout/plans	90% Design: An updated version of 60% Design with revisions and additional detail where applicable		X		X	6 weeks prior to start of relevant work	
Design	Site layout/plans	IFC Design: An updated version of 90% Design with revisions and additional detail where applicable		X		X		
Design	Site layout/plans	As-built Design: Design changes after the release of the IFC Design Documents and to document the design of the as-constructed facility.			X			
Design	Project controls drawings and documentation	30% Design: Operating description document, controls architecture block diagram, control devices specifications details		X		X	3 months after Agreement execution	
Design	Project controls drawings and documentation	60% Design: An updated version of 30% Design with revisions and additional detail where applicable.		X		X		
Design	Project controls drawings and documentation	90% Design: An updated version of 60% Design with revisions and additional detail where applicable		X		X	6 weeks prior to start of relevant work	
Design	Project controls drawings and documentation	IFC Design: An updated version of 90% Design with revisions and additional detail where applicable		X		X		
Design	Project controls drawings and documentation	As-built Design: Design changes after the release of the IFC Design Documents and to document the design of the as-consctucted facility.			X			
Design	Project auxiliary systems specfications and design drawings	30% Design: Includes specifications and design drawings of all elements of the electrical system including, but not limited to the following: • Switchgear connections, including connection diagram, in addition to individual equipment specifications and compliance certification. • Transformer specifications, including kVA rating, nominal voltage rating, insulating medium, thermal ratings, temperature rise, fault ratings, insulation ratings, IP level, corrosion protection, load and no-load loss guarantees, manufacturer and standards compliance. Design drawings, including enclosure. Transformer type test certificate and a fitness for purpose statement (considering Environmental Conditions, corrosion, cyclic loading, harmonics, peak voltages and fire risk). • Auxiliary power systems and associated equipment specifications, including battery and UPS capacities/back-up time • Revenue and power quality meter specifications		X		X	3 months after Agreement execution	
Design	Project auxiliary systems specfications and design drawings	60% Design: An updated version of 30% Design with revisions and additional detail where applicable.		X		X		
Design	Project auxiliary systems specfications and design drawings	90% Design: An updated version of 60% Design with revisions and additional detail where applicable		X		X	6 weeks prior to start of relevant work	
Design	Project auxiliary systems specfications and design drawings	IFC Design: An updated version of 90% Design with revisions and additional detail where applicable		X		X		
Design	Project auxiliary systems specfications and design drawings	As-built Design: Design changes after the release of the IFC Design Documents and to document the design of the as-consctucted facility.			X			
Design	Spare parts, tools, and permanent storage	30% Design including the following:				X		

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Category	Deliverable:	Description:	Level A	Level B	Level C	Owner Approval	Owner Proposed Schedule	Contractor Proposed Schedule
		• List of components and consumables that do not satisfy the Design Life for Work including additional information						
Design	Spare parts, tools, and permanent storage	60% Design: An updated version of 30% Design with revisions and additional detail where applicable. Detailed foundation design drawings required.		X		X		
Design	Spare parts, tools, and permanent storage	90% Design: An updated version of 60% Design with revisions and additional detail where applicable		X		X	6 weeks prior to start of relevant work	
Design	Spare parts, tools, and permanent storage	IFC Design: An updated version of 90% Design with revisions and additional detail where applicable		X		X		
Licenses	Software licenses	All licenses, software keys, hardware keys (dongles) and the like for all software included in the Works.			X			
List	Sub-contractors list	List of all sub-contractors to be included as approved sub-contractors.	X			X	Agreement close	
Manuals	O&M Manuals	Draft, comprising Overview and Manuals from key equipment suppliers; equipment maintenance requirements Per M4-01-01, Section 2.5		X		X	Per M4-01-01, Section 2.5	
Manuals	O&M Manuals	Complete and final O&M Manuals, including but not limited to (as applicable): • Overview of the Plant Works • All relevant specifications • All details for the safe and effective use, operation and maintenance of the complete Plant Works • Procedure to mitigate grease contamination from oil leaks or other contaminants that can enter blade bearing. • System description • Safety Plan with Supporting Lock-out-tag-out procedures • Equipment startup procedures • Equipment shutdown procedures • Equipment warning and trip setpoints • Normal system operations controls • Abnormal system operations controls • Equipment fault codes • Troubleshooting guides • Maintenance intervals and tasks; including: • Procedures • Tools • Inspection criteria, as required • Systems Descriptions describing normal and abnormal control for system components • Condition monitoring intervals and tasks; including: • Inspection procedures • Inspection criteria			X		Per M4-01-01, Section 2.5	
Manuals	SCADA system documentation	The SCADA system shall be supplied with three sets of comprehensive, complete and up-to-date documentation packages relevant to all the hardware and software supplied. This shall include but not limited to (as applicable): • A comprehensive user manual explaining the operation and use of all the functions			X			

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Category	Deliverable:	Description:	Level A	Level B	Level C	Owner Approval	Owner Proposed Schedule	Contractor Proposed Schedule
		• Detailed descriptions of the underlying theory and calculations employed especially with regard to availability and power curve measurements. These shall include complete details of any data processing carried out by the controllers • A complete electrical wiring diagram showing connections to the controller and the communications links • Hardware manuals for all hardware and computers systems • An administrator manual for system administration and configuration • Quality control, installation and commissioning documentation						
Permits	Permits	Permits including but not limited to: • 1200c (NPDES and Sediment and Erosion control) • Removal/fill • Septic • WPCF		X		X	5 business days upon obtaining	
Plan	Capacity test plan	Method Statement describing the Contractor’s proposal to perform Capacity Test and Availability Test in accordance with the requirements set in the Specifications. • Details of the equipment to be used • Any deviations • The methodology for dealing with those deviations • Details of the site calibration procedure		X		X	6 months after Agreement execution	
Plan	Civil works, concrete procedure	A procedure for on-Site concrete batching, including as a minimum: • Source of materials • Transport plan • Quality control If Contractor proposes to utilize a pre-existing off-Site batch plant, details shall be provided on the concrete supplier including: • Quarry materials suppliers and any additives required • How the delivery of concrete to site is to be managed Contractor shall additionally provide a method statement for forming cold joints should concrete supply be disrupted.		X		X	2 months after Agreement execution	
Plan	Critical Lift Plans	Plan shall clearly identify precautions for all critical lifts; coordination plans, including pre-lift meetings, with all participating personnel; and sample documentation/checklists for all critical lifts.		X		X	Prior to mobilizing to Project Site	
Plan	Document control plan	The document control plan shall address how documents are transmitted, named, reviewed, tracked, and edited.		X		X	2 weeks after Agreement execution	
Plan	Emergency response plan	Emergency response procedures and information		X			1 month prior to accessing Site	
Plan	Environment Management Plan	Including, but not limited to: • NPDES permit • SPCC Plan • Noxious weeds management plan • Cultural resources plan • Stormwater plan • Drinking water plan		X		X	1 month after Agreement execution	

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Category	Deliverable:	Description:	Level A	Level B	Level C	Owner Approval	Owner Proposed Schedule	Contractor Proposed Schedule
Plan	Environment Management Plan	Operations Phase SPCC Plan		X		X	Prior to Substantial Completion	
Plan	Geotechnical Execution Plan	The name, office location, and qualification statement for proposed geotechnical engineer. The proposed scope of subsurface investigation, including number, location, and depths of borings; anticipated plan for laboratory testing; and detailed descriptions of additional site investigation techniques, including thermal and electrical resistivity or other necessary testing.		X		X	Prior to initiating subsurface investigations	
Plan	Grounding and bonding plan	Plan and details, including fence as applicable		X		X	6 weeks prior to start of relevant work	
Plan	Hazardous Material Management plan	Plan includes spill and recovery procedures.		X		X	1 month prior to accessing Site	
Plan	HSE management plan	Updated and final. This shall include a comprehensive list of all HSE laws and Applicable Standards applicable to the Work		X			1 month prior to accessing Site	
Plan	Typical commissioning plan	Proposed installation and commissioning plan	X			X	Agreement close	
Plan	Installation and commissioning plan, Commissioning Test Manual	Procedure describing pre-commissioning and commissioning tests on all items in preparation for completion of individual Section of Works and to reach Substantial Completion.		X		X	30 days before start of comissioning	
Plan	Loss of grid power procedure	Provide procedures to achieve the aim of ensuring the Work is able to withstand periods without grid electrical power.	X			X	Agreement close	
Plan	Project management plan	Proposed Project Plan including: • List of key personnel with CVs • Project organization diagram • Project schedule including all milestone dates for completion of Work	X			X	Agreement close	
Plan	Project management plan	Including: • Construction project manager and key team members (including curricula vitae) • Project organization diagram • Communication plan • Permits, licenses, certifications and agreements required • Procurement and sub-contracting plan • Project schedule and payment milestones (as defined in Appendix 01 Exhibit 01 Annex 04 Milestone Payment Schedule) • Resource loading plan • Environment, health and safety plan including description of HSE system and associated certificates • Quality control / quality assurance plan (including equipment inspections and factory acceptance tests) • Management of Owner and other external interfaces • Change control plan – including change order process • Escalation matrix – how and when to escalate issue for resolution		X		X	30 days after Agreement execution	
Plan	Project quality plan	Proposed Quality Management Plans applicable to: • Design of the Work • Manufacture of the Work • Transportation and storage of the Work • Installation and erection of the Work		X		X	45 days following NTP	

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Owner Approval: Must be submitted for the Owner's review and approval prior to equipment purchase or construction

Category	Deliverable:	Description:	Level A	Level B	Level C	Owner Approval	Owner Proposed Schedule	Contractor Proposed Schedule
		• Testing, commissioning, and Substantial Completion of the Work • Shall include, where appropriate, references for FATs of major components • Description of quality management system and associated certificates						
Plan	Project quality plan	Update and final Project specific quality management plan		X			1 month following Owner comments	
Plan	Project schedule	The Schedule shall include, but not be limited to, the following: • Schedule Basis Memorandum • Engineering activities (i.e. engineering studies, calculations, and designs) • Procurement activities • Material and equipment deliveries • Construction activities • Tie-ins to existing plant systems • Equipment factory tests • Interfaces with Owner and other external interfaces • Major milestones • Milestone payments, if applicable • Startup and commissioning activities • Testing activities		X		X	8 weeks after NTP	
Plan	Site Specific Safety and Health Plan	Including elements as specified in Appendix M1 Attachment 01 Exhibit 06 – Safety, Health, and Environment. • Resumes of Safety Professional	X			X	Agreement close	
Plan	Solid Waste Recycling/Recovery plan	Plan for solid waste recycling and recovery.		X		X	1 month prior to accessing Site	
Plan	Storm Water Pollution Prevent Plan (SWPPP) or Sediment and Erosion Control Plan	As required		X		X	1 month prior to accessing Site	
Plan	Testing, inspection and test plans	Proposed testing plan including but not limited to: • Proposed commissioning procedures including but not limited to: o the Commissioning Tests o the Acceptance Tests o the Performance Tests o SCADA • Details of any Tests on Completion that may threaten the safety of the Plant		X		X	2 months prior to start of relevant work	
Plan	Training program	Details of training program required to support the off-site and in-field training of Owner's personnel.	X			X	Agreement close	
Plan	Training program	Hard and electronic copies of all training material.			X			
Plan	Transportation plan	Procedure for delivery to Site for main transformer, inverter stations and other critical equipment and oversize loads		X		X	1 month prior to Site mobilization	
Plan	Transportation plan	Proposed shipping and access routes and major onsite access plan	X			X	Agreement close	
Plan	Work plans	Procedures for execution of all Work including details of number of personnel and vehicles that will be on site at all the different phases of the Project		X		X	2 months prior to start of relevant work	
Report	As left settings	Alarm set points, complete I/O database including description of each I/O			X			
Report	Civil works 3rd party structural design report	Third-party Registered Professional Engineer's Report confirming the suitability of:		X			6 weeks prior to start of relevant work	

KEY

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Level C:	As-built Documentation - As-built drawings and other record documentation to be submitted after the issuing of any completion certificate
Owner Approval:	Must be submitted for the Owner's review and approval prior to equipment purchase or construction

Category	Deliverable:	Description:	Level A	Level B	Level C	Owner Approval	Owner Proposed Schedule	Contractor Proposed Schedule
		• The permanent buildings • Any other structures as required to be certified under the local building and/or structural codes						
Report	Civil Works Civil/Structural design report	The design report shall contain, as a minimum, all method statements, design inputs, design calculations, specifications, design drawings, cross sections, layouts and studies regarding: • HV/MV substation foundations/footings; • Access roads • Permanent buildings (including structural, architectural, fire rating and hold down details) • Site drainage • Site landscaping • Site restoration		X		X	3 months after Agreement execution	
Report	Document register	Proposal defining the contract drawings and documents in the form of a document register	X			X	Agreement close	
Report	Document register	Update of document register.		X				
Report	Electrical balance of plant power system studies and design calculations reports	Updated Electrical Design Report following any design changes during construction.			X			
Report	Electrical studies	Include Easypower/Aspen software model and complete system one line diagram, where applicable. Electrical studies including, but not limited to the following: • Auxiliary power study • Coordination study • Arc flash hazard study • Insulation coordination • Isolation transformer k-factor (or h-factor) calculation • DC/UPS sizing • Grounding calculation • Harmonics study		X		X		
Report	Electrical studies	Update and final report			X		One month prior to Substantial Completion	
Report	Electrical system optimization report	Final optimization of power cable and overhead conductor size		X			6 months after Agreement execution	
Report	Energy generation summary	Report summarising loss parameters and energy estimates for the Solar Project	X				Agreement close	
Report	Equipment list	List of all equipment		X				
Report	Equipment maintenance records	Maintenance records for equipment			X			
Report	Failure Modes and Effects Analysis	Provide for critical supplied systems and assets: • Known / common failure modes • Potential failure modes and historical/expected mean time between failures • Severity on operation relative to the system provided • Methods of detection based on vendor supplied Preventive Maintenance (PM) or Predictive Maintenance (PdM) Procedures • Improvements due to design modifications, additional PM or PdM measures or optional equipment.		X		X	3 months after Agreement execution	

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Owner Approval: Must be submitted for the Owner's review and approval prior to equipment purchase or construction

Category	Deliverable:	Description:	Level A	Level B	Level C	Owner Approval	Owner Proposed Schedule	Contractor Proposed Schedule
Report	Final substantial completion test reports	Completed installation and commissioning checklists, including commissioning test results, for the entire Plant electrical Works, including, but not limited to, MV/HV Transformer/s, auxiliary transformers, protection systems and switchgear, transformers and switchgear, MV cables, fiber optic cables, metering, LV equipment, in-line cable joints (if applicable), earthing connections, terminations and joints.			X			
Report	Foundations Civil/Structural design report	Including but not limited to the following: • Design loads for all structural components • Design calculations including all assumptions • Demonstration of suitability of all structural components in extreme wind conditions and over the design life • All partial safety factors • Decision trees • Reinforcement specifications and testing, and • Conclusions		X		X	3 months after Agreement execution	
Report	Geotechnical investigation report	Comprehensive geotechnical investigation, including and as applicable: • MV/HV Substation • Access Roads • Underground Cabling • Soil Resistivity (Electrical and Thermal) Surveys		X		X	2 months after Agreement execution	
Report	Grid connection documentation	Update to all required grid connection documentation.			X			
Report	HSE report	Final HSE report and risk register			X			
Report	HV/MV electrical system design report	Design of proposed electrical systems including, but not limited to: • Single Line Diagrams (SLD) for MV/HV Substation incorporating protection (or provided separately) • Earthing general arrangement (GA) drawings and schematic diagrams • Substation GA drawings, including overall GA drawing, MV switchroom GA drawings (including MV and LV switchboards, protection panels, SCADA, battery / UPS, chargers, etc.) • Schematic diagrams and distribution board schedules for MV switchroom equipment, LV supplies and metering • Details of equipment redundancy • Electronic copies of all studies, models, rating evaluations, etc. performed for the above requirements. Specific software and version information to be provided by Owner.		X		X	6 months after Agreement execution	
Report	Hydrology and flood study	To confirm the design for flood requirements for a 1 in 100-year flooding event.		X		X	Prior to relevant design work	
Report	Installation and commissioning reports	The results of all inspections, checks and tests carried out, together with any subsequent analysis. Including but not limited to protective relay calibration tests, trial of equipment operation summary, and manufaturer field service reports.			X		Within 30 business days of commissioning	
Report	Lightning protection study	Detailed assessment of lightning risk to personnel and Works in accordance with Applicable Standards.		X		X	2 months prior to start of relevant work	

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Owner Approval: Must be submitted for the Owner's review and approval prior to equipment purchase or construction

Category	Deliverable:	Description:	Level A	Level B	Level C	Owner Approval	Owner Proposed Schedule	Contractor Proposed Schedule
Report	Master drawing list	Table of all drawings including drawing number, revision letter/number, revision date, drawing title, discipline, document status, document type, plant system, and cross-reference listing for associated vendor drawing numbers, and date submitted to PGE for review.		X		X	As drawings are submitted	
Report	Meeting minutes	Meeting summary and reports		X	X		3 days following meeting	
Report	Project schedule	Update as monthly progress reporting showing status, variance, constraints, actual versus planned progress.		X	X	X	monthly	
Report	Project status report	Weekly template provided by Owner. Monthly report to include, as a minimum, for that month: • Safety statistics, issues, and events • Summary of events including equipment delivery dates and status • Major activities accomplished during past month and those planned for the coming month • Project schedule update • Milestone payment schedule status • Earned Value Quantities Report (EVQR) • Contract progress S-curves • Contract overall man-hours S-curves • Contract overall staffing histograms • Contract overall craft histograms • Key quantity S-curves • Risks, delays, and quality concerns		X	X	X	monthly and weekly	
Report	Project workbook	List of Project documentation			X		Prior to Final Completion	
Report	Punch list	Documentation listing and detailing any and all minor non-conformances and proposed rectification not required to be completed prior to Substantial Completion.			X			
Report	Quality assurance package	Complete sets of quality assurance documentation for each of the defined construction milestones referenced in the Specifications (commonly recorded via construction job books).			X			
Report	Risk assessment report	Risk Assessment Analysis		X		X	30 days after Agreement execution	
Report	Risk assessment report	Periodic submission of risk report showing updates and control measures		X			As updated	
Report	Special tools and vehicles	List of all the tools, vehicles or voice communications equipment required for the safe and effective operation and maintenance of the Plant stating whether the Employer is required to purchase this equipment or not.	X			X	Agreement close	
Report	Special tools and vehicles	Update to special tools and vehicles list		X			6 months after Agreement execution	
Report	Storage records	Storage records for any equipment, materials, or other work that was previously produced, manufactured, or constructed, per Section 1.5.11 of Attachment M1-01-02.		X		X	Prior to shipment from original storage location	
Report	Test reports	The results of all inspections, checks and tests carried out, together with any subsequent analysis including documentation of all Acceptance, and Performance Tests (if complete) and applicable certifications. The final commissioning test summary shall be prepared and document the results of all commissioning tests. • Any mutually agreed upon deviations from the Commissioning Test Manual procedures • Instrument calibration sheets and certificates • Test data, including corrected test data			X	X	Within 5 days after test completion	

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Owner Approval: Must be submitted for the Owner's review and approval prior to equipment purchase or construction

Category	Deliverable:	Description:	Level A	Level B	Level C	Owner Approval	Owner Proposed Schedule	Contractor Proposed Schedule
		• Field notes (weather conditions, observations, etc.) • Test calculations • Any deficiencies or issues identified during, or as a result, of testing • Conclusions • Signatures of Contractor and Commissioning Manager						
Report	Transformer field inspections and tests	Upon delivery to the Site, transformer supplier shall perform and record the following: • Check impact recorder • Check blocking • Check transformer trank and fittings • Inspect bushings • Internal inspections - moister, coil supports, etc. • Check all parts have been delivered • Perform field tests and compare to FAT • Check all accessories • Provide all additional field inspections, adjustments, and tests recommended by the transformer manufacturer.			X		Within 5 days of delivery	
Specifications	Civil works specifications	Where not covered by the Site Layout, an outline of proposed BoP/BOS Civil Works, including but not limited to: • Overview, specifications • Details of reinforcement • Site testing	X			X	Agreement close	
Specifications	Contractor specifications	Including the following: • Standards as identified by Contractor as being relevant to the Work • Equipment suppliers detailing locations, and where major components of the Work shall be manufactured	X				Agreement close	
Specifications	Grid connection documentation	All required information to assist Owner in its application for Grid Connection.	X	X		X	Duration of Agreement	
Specifications	Grid connection documentation	Including: • Generating System Design Data Sheets • Contractor shall supply a completed performance standard template stating the proposed level of compliance to each access standard in accordance with the TSP's GPS		X			Duration of Agreement	
Specifications	HV/MV transformer specifications	Proposed substation transformer specification which shall include at a minimum the following details: • Transformer layout • Ratings and Design Life • Auxiliary Supply • Radio Interference • Short Circuit Withstand Capacity • Earth Tremors • Insulation Levels • Noise Levels and Vibration • Temperature Rise Limits • Magnetising Current and Flux Density • Transformer Core and Windings • Transformer Losses	X			X	Agreement close	

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Level C: As-built Documentation - As-built drawings and other record documentation to be submitted after the issuing of any completion certificate
Owner Approval: Must be submitted for the Owner's review and approval prior to equipment purchase or construction

Category	Deliverable:	Description:	Level A	Level B	Level C	Owner Approval	Owner Proposed Schedule	Contractor Proposed Schedule
		• Transformer Construction • Transformer Tank • Transformer Oil and Valves • Oil Conservator Tank • Cooling Equipment • Temperature Measuring Equipment • Gas and Oil Actuated Relay • Pressure Relief Devices • Gaskets and Flanges • Marshalling Box • Auxiliary and Control Wiring • Terminations • Bushings • Surge Diverters • Degree of Polymerisation (DP) • Inspection and Testing • Shipping						
Specifications	Inverter specifications	The following documents shall be submitted by the Contractor. • Datasheet • Track records • Type test certificates to Applicable Standards and test reports • Accelerated test certificates • Warranty terms	X			X	Agreement close	
Specifications	Manufacturer storage specifications	Manufacturers' storage and protection requirements/recommendations for all equipment and materials should be provided to Owner prior to delivery		X		X	1 month prior to delivery	
Specifications	Material safety data sheets	As required		X			As received	
Specifications	Permanent on-site buildings	Functional description and preliminary design specifications including: • Layout • Elevation drawings • Structural • Architectural • Fire rating • Hold down	X			X	Agreement close	
Specifications	SCADA and communications network	Functional description and preliminary design specifications including: • Information on the communications system, including specifications and drawings • Information on the SCADA system, including specifications and drawings	X			X	Agreement close	
Specifications	SCADA instrumentation specifications	Copies of calibration sheets for all sensors/transducers as appropriate in accordance with the appropriate calibration standards. Sensors/transducers shall include those mounted on: • Switchgear • Monitored equipment • Statcom equipment, and • Power Quality Metering			X			
Specifications	Substation specifications	Functional description and preliminary design specifications including:	X			X	Agreement close	

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Owner Approval: Must be submitted for the Owner's review and approval prior to equipment purchase or construction

Category	Deliverable:	Description:	Level A	Level B	Level C	Owner Approval	Owner Proposed Schedule	Contractor Proposed Schedule
		• Substation general arrangement drawing • Reactive power compensation resources (if applicable) • Reactive power compensation support and voltage control philosophy • Protection philosophy • Primary and secondary system key equipment specifications • HV and MV switchgear, neutral earthing resistors or neutral earthing transformers (if applicable)						
Specifications	Welding procedure specfications	Document demonstrating welding procedure shall meet all requirements of the AWS D1.1 code		X		X	6 weeks prior to start of relevant work	

APPENDIX M1

ATTACHMENT 01

EXHIBIT 05

PROJECT MANAGEMENT AND CONTROLS

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

REQUEST FOR PROPOSAL

NO.	DATE	REVISION	BY	CHK'D	APPROVALS	
0	11Dec17	Issued for Implementation	DNV-GL	DS	CPA	Craig Armstrong
1	14Apr23	Update from 2021 Version	PGE		CPA	Craig Armstrong

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1.0 PROJECT CONTROLS

1.1 GENERAL

The Contractor shall provide a project management plan, detailed project schedule, milestone or progress payment schedule, progress reports, and other information necessary for the completion of the facility on time and within budget. The scope of this shall include all work in all phases of the project for which the Contractor is responsible.

1.2 KICK OFF MEETING

As a first step, Contractor shall organize a kick-off meeting with Owner and subcontractors, with the following objectives:

1. Learn about the Project, update timeline, and short-term and medium term priorities and discuss other key points and expectations
2. Introduce the team that will be working on the project and their roles and responsibilities
3. Establish document control method (see Section 1.3)
4. Identify time and frequency of conference call
5. Identify main point(s) of contact and discuss communication protocols and timeframes for response
6. Discuss any risks to the project and potential mitigation measures
7. Discuss escalation procedures
8. Discuss contract administration

Contractor shall have project managers and any other representative in attendance during the kick-off meeting.

1.3 DOCUMENT CONTROL

Contractor and Owner shall discuss and agree upon a document control plan. The document control plan shall address how documents are transmitted, named, reviewed, tracked, and edited in compliance with the requirements in Appendix M1 Attachment 01 Exhibit 02 – Engineering Documents, Drawings & Other Deliverables. A data room shall be set up that Contractor and Owner can effectively use.

1.4 PROJECT MANAGEMENT PLAN

Contractor shall develop a project management plan for the management and execution of all phases of the Work within 30 days of contract execution, and shall address as a minimum:

1. Construction project manager and key team members (including curricula vitae)
2. Project organization diagram
3. Communication plan

4. Permits, licenses, certifications and agreements required
5. Procurement and sub-contracting plan
6. Project schedule and payment milestones
7. Resource loading plan
8. Environment, health and safety plan (initial draft or outline)
9. Quality Management System plan
10. Management of Owner and other external interfaces
11. Change control plan – including change order process
12. Escalation matrix – how and when to escalate issue for resolution

Contractor shall identify project manager(s), project scheduler, cost controller, risk matrix manager, and documentation manager for the Project.

1.5 SCHEDULE

The Contractor shall furnish a detailed, minimum level 3[1], Project Schedule, referred to as "Schedule", for its scope of work utilizing the Critical Path Method (CPM) 8 weeks after Notice to Proceed (NTP). The Schedule shall include, but not be limited to, the following:

1. Engineering activities
2. Procurement activities
3. Material and equipment deliveries
4. Construction activities
5. Tie-ins to existing plant systems
6. Equipment factory tests
7. Interfaces with Owner and other external interfaces
8. Major milestones
9. Milestone payments, if applicable
10. Startup and commissioning activities
11. Testing activities

Along with the detailed level 3 schedule, the Contractor shall furnish a Schedule Basis Memorandum. The Schedule Basis Memorandum shall include, but not be limited to, the following:

1. Project description

2. Project scope

    a. Provide work breakdown structure (WBS)

3. Schedule methodology

[1] As defined by AACE International (Association for the Advancement of Cost Engineering)

a. Key milestones and interface milestones

b. Schedule duration basis (i.e. time estimates)

c. Schedule assumptions (e.g. workweek, resources and equipment availability)

d. Project schedule settings (i.e. activity type, duration type, default scheduling options)

e. Summary of activities on the critical path

f. Execution strategy summary for engineering, procurement, construction, installation, testing and commissioning

4. Risk and opportunity analysis

    a. Summarize key risks that could delay the schedule

    b. Summarize strategies to mitigate key risk

5. Major constraints

    a. Key dates and constraints

6. Scheduling team

    a. Names and roles

The Schedule shall be resource loaded and be of sufficient detail to assure adequate planning and execution of the work, such that, in the judgment of Owner, it provides an adequate basis for monitoring and evaluating the progress of the work. This plan shall include and highlight all non-contractor interface points with the Owner, vendors or other external entities that could impact the Contractor's Schedule and execution plan. Owner will assume overall schedule integration to assure linkage of those non-contractor interfaces within the Schedule. After the Notice to Proceed, the Contractor shall update their project Schedule monthly as part of the monthly progress reporting. The Contractor shall also prepare, during construction, a rolling three-week Gantt chart schedule, updated weekly, for review at each progress and coordination meeting.

The Contractor shall use Oracle/Primavera P6 scheduling software, or Owner approved alternate software, that is based on network logic and will display the schedule critical path. Schedule performance shall be measured against a fixed project baseline schedule approved by the Owner. Initial schedule submittal and monthly updates shall be in PDF format along with the native file from the scheduling software.

A written schedule analysis shall be prepared as part of the monthly progress reporting. The analysis shall include Schedule status, variance, and constraints, including actual versus planned progress as indicated by the initial baseline Schedule (and any updates thereof), with reference to the major milestones and Schedule. All Schedules shall be configured to calculate data as follows:

1. Retained logic
2. Total float calculations based upon finished data
3. Contiguous scheduling
4. Start-to-start lags calculated from actual start dates
5. Percent completion and remaining completion not linked

All updates shall comply with the following requirements unless specifically altered in writing from Owner:

1. Contractor's construction schedule shall be carried out to support the overall project Schedule and key milestones identified in the Engineering, Procurement and Construction Contract
2. It shall be the Contractor's responsibility to maintain the progress of its Work in accordance with the Schedule
3. The Contractor, at its option and at no cost to Owner, shall develop additional schedule procedures it deems necessary to control and manage its work

All Schedules required by this specification are subject to Owner review and acceptance. Owner shall reject any Schedule or report that fails to show timely completion of the Work or any contract milestone date, or otherwise indicates unrealistic performance.

1.6 PROJECT STATUS REPORTING

The Contractor shall prepare and provide, at a minimum, a monthly and weekly progress report to the Owner. The monthly report content requirements are listed below. A weekly report template will be provided by the Owner and will include daily weather records and reporting major activities during the past week and those planned for the next three weeks. Weekly major activity reporting shall cover equipment delivery dates and status. An alternate template may be used upon Owner approval. The monthly report shall be issued to the Owner by the 10th day of the month following the month being reported, commencing upon notice to proceed. The weekly report shall be issued to the Owner by 4:00 pm, local time, every Friday, commencing upon notice to proceed.

The monthly report shall include, as a minimum, for that month:

1. Safety statistics, issues, and events
2. Summary of events including equipment delivery dates and status
3. Major activities accomplished during past month and those planned for the coming month
4. Project schedule update
5. Milestone payment schedule status

6. Earned Value Quantities Report (EVQR)
7. Contract progress S-curves
8. Contract overall man-hours S-curves
9. Contract overall staffing histograms
10. Contract overall craft histograms
11. Key quantity S-curves
12. Risks, delays, and quality concerns

The Contractor shall also prepare and submit to the Owner the Semi-Annual Construction Report as required by the applicable Site Certificate or state or local governmental siting process during the construction and commissioning phases only. Contractor shall prepare other permit required reports, as applicable.

1.6.1 EARNED VALUE QUANTITIES REPORT (EVQR)

This is a tabular report where contract quantities are reported showing quantities completed on monthly basis. This is the report that shows actual % complete, productivity, earned value, etc. on a monthly basis. Contractor is required to finalize the format and submit with contract quantity data within 4 weeks of award of contract/notice to proceed.

1.6.2 CONTRACT PROGRESS S-CURVES

This is a graph showing the cumulative and period plan, actual, and forecast progress on a weekly basis. The plan progress curves should be derived from the resource loaded Schedule and is to be submitted within 4 weeks of award of contract/notice to proceed. Thereafter when the work starts, the actual progress as derived from the EVQR should be plotted on the same graph against the plan. The Schedule is to be updated with the actual progress on a monthly basis. The forecast progress curve should be derived from the Schedule thus updated accordingly.

1.6.3 CONTRACT OVERALL MAN-HOURS S-CURVES

This is a graph showing the cumulative and period plan, actual, and forecast craft hours on a weekly basis. The plan craft hours curves should be derived from the craft hour loaded Schedule and are to be submitted within 4 weeks of award of contract/notice to proceed. Thereafter when the work starts, the actual craft hours spent as derived from the EVQR should be plotted on the same graph against the plan. The Schedule is to be updated with the actual craft hours on a monthly basis. The forecast craft hours curve should be derived from the Schedule thus updated.

1.6.4 CONTRACT OVERALL STAFFING HISTOGRAMS

This is a bar graph showing the overall weekly staffing (e.g. craft, home office team, management, etc.) planned, actually employed, and forecast (if different from plan). This should be derived from the resource loaded Schedule.

1.6.5 CONTRACT OVERALL CRAFT HISTOGRAMS

This is a bar graph showing the overall weekly craft manpower planned, actually employed, and forecast (if different from plan) broken down into various crafts. This should be derived from the craft hour loaded Schedule. A composite bar graph is acceptable for 1.4.4 and 1.4.5.

1.6.6 KEY QUANTITY S-CURVES

This is a graph showing the cumulative quantities plan, actual installed, and forecast to be installed on a weekly basis. Key quantities should be selected for this graph. Some of the key quantities (will differ from contract to contract) are excavation, back filling, concrete poured, structural steel, underground piping, aboveground piping, cable trays, cables, equipment to be installed, instruments, electrical terminations, etc. The plan curves should be derived from the quantity loaded Schedule and is to be submitted within 4 weeks of award of contract/notice to proceed. Thereafter when the work starts, the actual progress as derived from the EVQR report should be plotted on the same graph against the plan. The Schedule is to be updated with the actual progress on a monthly basis. The forecast progress curve should be derived from the Schedule thus updated. Since this process as mentioned above is required to continue on a monthly basis, Contractor is requested to plan the scheduling process in a way that the monthly updating of the Schedule with actual progress is managed well within the Contractor's capability.

1.6.7 CONTRACT DELIVERABLES LOG

This is a log of the required deliverables from the Contract. The deliverables log will be created by the Owner within 30 days of the notice to proceed, then tracked and updated by the Contractor on a monthly (or more frequent) basis.

1.7 ON-SITE STATUS & COORDINATION MEETINGS

During construction, startup and commissioning, the Contractor will hold a weekly on-site meeting that includes their key field personnel and the Owner project team. The purpose of these meetings is to review the weekly status report and to discuss current status, the three-week rolling schedule, coordination issues, and any significant concerns or problems that require action.

Commencing a month after project notice to proceed, Contractor will hold a monthly meeting that includes their key personnel and the Owner project team. The purpose of these meetings is to review the monthly progress report and to discuss current status, the Schedule, coordination issues, health and safety issues, and any significant concerns or problems that require action.

Additional project meetings to facilitate construction and communication may be required as well. Contractor shall hold a meeting prior to tower erection with Owner.

1.8 RISK ASSESSMENT

The Contractor shall furnish a Risk Assessment Analysis for their scope of work identifying major risks, probability of occurrence, possible impact, and actions that can be taken to mitigate any adverse effects. A Risk Matrix template is available from the Owner. The assessment shall be completed within 30 days of contract execution and updated monthly or more often as conditions or events warrant and submitted to the Owner. Specific risk items that were/are active during the previous month or next three months shall be included in the monthly report.

Appendix M1

Attachment 01

Exhibit 07

Security and Compliance

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

REQUEST FOR PROPOSAL

NO.	DATE	REVISION	BY	CHK'D	APPROVALS	
0	26Oct21	Issued for Implementation	1898 & Co.		JAL	Jared Lathrop
1	14Apr23	Update from 2021 version	1898 & Co.	PGE	CPA	Craig Armstrong

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1 General

1.1 Specifications

In addition to specifications outlined herein, Contractor shall comply with the requirements provided in M1-05-04 (Communication, SCADA, and Metering Facilities). Additional requirements based on project type (wind, solar, or energy storage) shall comply with the respective requirements in M2-01-01 (Wind Plant Specifications), M3-01-01 (Solar Photovoltaic Plant Specifications), and M4-01-01 (Energy Storage Technical Specifications).

2 SCADA Cyber Security

In this section, the term “SCADA” specifically refers to the plant control system. This is not intended to influence or dictate requirements for the substation or Transmission System Operator.

Contractor shall incorporate all security appliances in the collector substation control house and Owner’s security center into the SCADA system. SCADA system to be compliant with NERC Critical Infrastructure Protection (CIP) and Owner’s internal standards.

In the event Owner is responsible for maintaining the SCADA system and/or performing day-to-day operations at the site, Owner shall have input on which security applications are used to conform with internal requirements. If Owner is not performing any day-to-day maintenance the operator shall have say of specific applications, but the requirements still apply.

2.1 Patch Management

Contractor will include a patch management system capable of deploying patches for all software, hardware, and integrated third-party applications within the SCADA system.

Contractor will evaluate, test, and provide appropriate patches to all devices and software within the SCADA system or any other provided system.

Contractor will install patches on all systems according to industry best practices to reduce operational risk due to cyber incidents. At minimum, patches should be installed on an annual basis.

2.1.1 Anti-Virus & Whitelisting

Contractor will supply an anti-virus and whitelisting system capable of managing all assets within the SCADA system.

Contractor will install whitelisting software on all Windows and Unix-based endpoints within the SCADA system and have a procedure to keep the system in restricted (blocking) mode while the system is operating.

Contractor will install anti-virus software on all Windows-based endpoints and provide ongoing definition updates according to industry best practices to reduce operational risk due to cyber incidents. At minimum, definitions should be updated on a monthly basis.

Contractor will provide a list of all applications that need to be whitelisted on all provided equipment.

2.1.2 Backup and Restoration

Contractor will provide a backup and management system capable of taking operating system backups of all SCADA equipment for the purposes of rapid restoration in the event of a system failure or cyber incident.

Contractor will install backup and restoration software on all Windows and Unix-based devices within the SCADA system. The system must be configured to take automated backups and Contractor must have a procedure for validating backup validity.

Other devices within the SCADA system and support systems (such as networking devices) must be configured to have their configurations, firmware, and any other applicable configuration files pulled automatically on a scheduled basis.

Backups may be stored locally to the site; however, an offline backup must be maintained for incident recovery. The offline backup must be regularly updated, at minimum once per year.

2.1.3 Security Logging

Contractor will provide a log management system capable of collecting, analyzing, and alerting on logs generated by the SCADA system.

All Windows, Unix, and Syslog-capable devices within the SCADA system must be configured to send logs to the log management system.

Log management system must be continuously monitored by a Security Operations Center (SOC) using industry best practices for log correlation and incident reporting.

Contractor must inform PGE of any event or incident that could detrimentally affect the operations of the SCADA system within 24 hours of when it was detected.

Contractor will provide a log management system capable of collecting, analyzing, and alerting on logs generated by the SCADA system.

2.1.4 Vulnerability Management

SCADA Contractor will provide a mechanism for alerting Owner in the event of a vulnerability or exploit that affects the SCADA system within 10 working days after discovery.

SCADA Contractor will disclose the existence and reasons for any identified backdoor codes.

2.2 System Management

In the event Owner is responsible for maintaining the SCADA system and/or performing day-to-day operations at the site, the following requirements apply. If Owner is not performing any day-to-day maintenance, this section does not apply.

2.2.1 Device Management

Contractor will turn over management of all servers, applications, application and networking devices within the SCADA system or any other provided system to the Owner at the conclusion of the SAT. This will include Domain Administrator privileges.

Contractor must provide validated patches for the system for all provided equipment for operational life of this equipment.

Contractor will provide information on all required communications through the firewalls prior to the factory acceptance test.

Contractor will properly harden all devices including uninstalling unused software components and disabling unnecessary services and ports prior to the site acceptance test.

Contractor will provide documentation detailing all applications, utilities, system services, scripts, configuration files, databases, and all other system requirements during the site acceptance test.

2.2.2 Account Management

Contractor will supply or integrate with an Owner-provided domain controller to manage all authentication within the SCADA system and all support systems.

All default and guest accounts must be removed prior to the factory acceptance test.

Contractor will supply a list of accounts which need to be active on the SCADA system. These accounts must be approved by the Owner.

All accounts within the SCADA systems and support systems will adhere to least privilege permission schemes.

All passwords will adhere to Owner's password policy.

Contractor will notify Owner within 24 hours of an employee, who has access to the SCADA system or any support system, quits or is terminated with cause.

Contractor will notify Owner within 3 days when an employee, who has access to the SCADA system or any support system, retires or changes position, or otherwise no longer needs access to the system.

No local accounts will be enabled within the generation SCADA system.

Contractor will provide all password change procedures/requirements during the site acceptance test.

2.3 SCADA Network Design

2.3.1 Network Segmentation

The individual SCADA system components must be logically segmented from each other. The following networks shall remain separate where technically feasible:

a. Domain Controllers
b. SCADA Servers
c. User workstations
d. Controllers/PLCs
e. Auxiliary Systems
f. Monitoring systems
g. Terminal/VPN Servers
h. Independent strings/loops of remote devices

Contractor will provide and enforce ACLs and port security address lists for all communications between subnets.

Contractor will provide and document secure network architecture where higher security zones originate communications to less secure zones.

All unencrypted protocols (FTP, telnet, HTTP, etc.) shall be disabled in lieu of their encrypted counterparts (SFTP, SSH, HTTPS, etc.).

2.3.2 Wireless Communications

Wireless technologies such as microwave, cell, Bluetooth, Wi-Fi (802.11x), ZigBee, WirelessHART, or other wireless technologies shall not be used within the SCADA system.

2.3.3 High Availability and Redundancy

All critical systems, to be jointly determined by Owner and Contractor, shall have redundant hardware and software operating in a high-availability mode.

2.3.4 Network Space

In the event Owner is responsible for maintaining the SCADA system and/or performing day-to-day operations at the site, the following requirements apply. If Owner is not performing any day-to-day maintenance, this section does not apply.

Owner will provide Contractor with banks of IPs that can be used for devices within the SCADA system or other support systems.

Contractor will provide Owner with a list of devices with associated IP address prior to the factory acceptance test.

2.3.5 Security Design Workshops

In the event Owner is responsible for maintaining the SCADA system and/or performing day-to-day operations at the site, the following requirements apply. If Owner is not performing any day-to-day maintenance, this section does not apply.

Owner, Contractor, and any pertinent subcontractor (including SCADA Contractor) will have at minimum 5 security design workshops lasting no less than one hour each.

These interactive meetings will allow the Contractor to present the methods used for conforming to the requirements of PGE Cyber Security Policies and Procedures and relevant compliance requirements.

The minimum topics that will be covered in these workshops are:

a. Review of requirements
b. Presentation of hardware and software products to be used.
c. Implementation plan
d. Long term system maintenance, operation, and support requirements
e. Network design and requirements

2.4 Remote Access

All remote access traffic must be fully encrypted.

All remote access where a user interfaces with any part of the SCADA system or support system will require multi-factor authentication.

Under no circumstances will the SCADA system or any support system have direct access to the internet.

All remote access to the control system network must be performed through a VPN.

VPN connections must have logging, alarming, and monitoring to protect SCADA system from unauthorized modification or use.

2.5 Incident Response/Disaster RecoverY

Contractor shall provide existing Incident Response and Disaster Recovery plans for the SCADA network.

Contractor shall work with the Owner to address deficiencies in Contractor's Incident Response and Disaster Recovery plans.

2.6 Site Acceptance Test

Prior to the site acceptance test the Contractor shall:
- Ensure all devices are patched to their most current level.
- Provide current configuration files for all devices.

Firewall rules, as well as all other access control mechanisms, will be enabled throughout the duration of the SAT.
All Firewall rules and router ACLs will be verified at the SAT.
Remote access and remote access restrictions must be tested as part of the SAT.

2.7 Physical Security

Contractor shall provide a lockable or locking enclosure for all control system components.

All physical security networks must be separate from SCADA networks.

3 Generation Physical Security System

3.1 General Design

Contractor shall provide the necessary below grade, and above grade infrastructure for PGE's security system that includes, but is not limited to the following requirements:

A centralized point for the security system and cabling to be housed and secured, either on a concrete foundation and an outdoor rated 4 post communications rack with a heating and cooling system, or adequate wall space of 8' X 8' in an indoor location or an indoor rated 4 post communications rack mounted in a temperature controlled secured room to be provided by Contractor.

All underground conduits provided by the Contractor and will be a minimum of 2" PVC routed from the centralized location to the appropriate point and stubbed up and capped with an 8" X 8" Non-metallic weatherproof enclosure unless otherwise specified.

There will be (1) conduit provided by the Contractor from the centralized area to the closest point on the fence line stubbed up 24" – 30 "for the Fence Detection System. If the Fence line is more than 2,600' in length, another conduit will also be needed and will be identified during design for placement.

There will be (1) conduit provided by the Contractor from the centralized location to wherever the PGE communication equipment is housed to provide a communications pathway for the security system. If both systems are housed internally inside the same rack or building, it is acceptable to use cable tray if it is available in leu of conduit.

For each gate either personnel or vehicle there will be (1) conduit provided by the Contractor under each gate stubbed up 24”-30” and 12”-20” for both edges of the gate.

For each gate either personnel or vehicle there will be (1) conduit provided by the Contractor for the access control and Intrusion detection systems back to the centralized security location.

There will be enough camera locations within the project’s exterior within the footprint of the fence line to view the entire area without obstruction. This may require the Contractor to install footings and poles. PGE’s preference for these poles is a 16’-20’ non-metallic pole.

All internal locations may have camera coverage depending on type of work location:

a. Substation Control House – 100% coverage
b. Switchgear building – 100% coverage
c. Communications Room – 100% coverage
d. Control system Room – 100% coverage
e. All others to be determined during design process

All building external doors shall have a Contractor provided pathway for a camera that is mounted to the building to cover the entrance of the external door that goes to the centralized security system.

For all buildings there will be a location for at least (1) intrusion detection keypad and (1) access control card reader typically mounted near the main entry point and will require the Contractor to provide the pathway though the building and to the centralized security system location and mounting boxes for the equipment.

For all external doors to any building, the Contractor will provide pathway and mounting boxes for the needed security requirements, which will include at a minimum, but is not limited to door contact, REX, electronic locking mechanism, and card reader.

For all internal building doors, there will be a discussion during design on whether to secure any doors with a security system, the one exception to this is an internal communications room will require access control and this pathway through the building and to the centralized security system, and mounting boxes will be provided by Contractor at a minimum to meet the same requirements as an external door.

All keyways on all doors must be capable of housing an E-Lock core made by Assa-Abloy

All doors with access control must have electrified door lever sets with integrated request to exit devices and power door hinges.

3.2 Site Lighting

Site lighting shall be provided at the following locations:

a. All plant vehicle and pedestrian entrances
b. Entry doorways to all buildings
c. Parking areas
d. Substation or switchyard

Site lighting shall include light fixture, mounting poles, lighting controls, etc., as applicable.

Light fixtures shall be suitable for outdoor locations in wet locations.

Light fixtures shall be light emitting diode (LED) type.

All site lighting equipment shall be UL listed.

Lighting control shall consist of a HAND-OFF-AUTO switch.

Photocells shall be used for automatic control.

Photocells shall be weatherproof, swivel adjustable, with built-in time delay to prevent accidental turnoff by momentary brightness.

Photocells shall be rated at 1800 VA, 120 volts ac.

Photocells shall be field adjustable from 1 ft/c turn-on to 15 ft/c turn-off.

Site lighting fixtures shall be installed in accordance with the equipment manufacturer’s installation instructions.

Lighting fixtures shall be installed plumb and level and aimed as specified on the drawings, as applicable.

For storage projects, other applicable requirements in M1-05-03 (Substation Design and Construction Specification)

3.3 Security Fencing Perimeter with Gates

8-foot high mini-mesh or expanded metal fencing with 3 barbed wire strands, as specified below or as approved by Owner

a. Fence fabric shall be 1” mesh, #9 gauge wire, Class 2 Zinc-coated steel.
b. End, corner, and pull posts shall be type 1, 2.375 inch nominal outside diameter and be hot dipped galvanized with a minimum average zinc coating of 1.8 oz./ft.2 (0.55 kg/m2) meeting ASTM F-1083 for standard weight (Schedule 40) galvanized pipe.

c. Tension wire shall conform to ASTM A-824 Type I, Aluminum-coated, 0.40 oz/ft2 (122g/m2) or Type II Zinc-coated Class 2, 1.20 oz/ft.2 (366g/m2)

d. Post tops shall consist of ornamental tops or combination tops with barbed wire supporting arms, as required. When so required, or when a top rail is to be provided, the top shall be provided with a hole suitable for the through-passage of the top rail. The post tops shall fit over the out-side of posts and shall exclude moisture from posts.

e. Tension bars shall not be less than 3/16 inch (4.76mm) by 3/4 inch (19.05mm) and not less than 2 inches (50mm) shorter than the normal height of the fabric with which they are to be used. One tension bar shall be provided for each end and gate post, and two for each comer and pull post.

f. Ties or clips of adequate strength shall be provided in sufficient number for attaching the fabric to all line posts at intervals not exceeding 15 inches (380mm); and not exceeding 24 inches (610mm) when attaching fabric to top rail or tension wire.

Powered, keycard-controlled sliding or swinging gate

a. One for access to O&M building entrance/parking area

b. One for access to storage/laydown area

c. Both of widths large enough to provide easy ingress to the facility for a full-size tractor trailer combo

4 Substation physical Security

The Project Substation shall meet the same physical security requirements as the rest of the site and as noted in this specification.

The Project Substation shall have access detection, control, and monitoring provisions to ensure that Owner is able to capture, record and monitor all personnel, authorized or unauthorized that enter the site area and must be compatible with Owner's existing security system. Contractor shall coordinate the preferred access control methodology with Owner along with additional provisions such as video monitoring and motion detection.

5 NERC and WECC Compliance

Contractor shall proactively consider NERC and WECC Compliance in the Project. New facilities connecting to the Bulk Electrical System (BES) require significant coordination with affected entities and specific planning and timely milestones will be required. The contractor will establish a schedule to ensure adherence to any standard issued by the North American Electric Reliability Corporation (NERC) or the Western Electric Coordinating Council (WECC) allowing for or applicable to the commissioning and operation of the Project.

Below are the current standards the contractor is expected to comply with:

1. **BAL-005-0.2b R1.1:** Generation facilities must be included within the metered boundaries of a Balancing Authority.

2. **BAL-005-0.2b R12:** Tie Line metering requirements
3. **CIP-002 R1:** Generator Owner will determine BES impact for generation resources.
4. **CIP-003 R2:** Generator Owner will implement controls to ensure low impact rating is met for all applicable CIP requirements.
5. **EOP-005-2 R4:** System Restoration Plan must be submitted to Peak for approval before any planned BES modification that would change the implementation.
6. **FAC-008-3 Facility Ratings:** Contractor to provide facility rating documentation of installed components.
7. **IRO-010/TOP-003:** There are a number of data specifications requiring modeling information to be submitted to Peak and others 30 days before the change to the network.
8. **MOD-001-2 R2:** ATCID methodology must take into account generation and transmission additions.
9. **MOD-025-2 R1 and R2:** real and reactive power capability verification
10. **MOD-026-1 R2 and R4:** generator excitation control system or plant volt/var control function model verification
11. **MOD-027-1 R2 and R4:** turbine/governor and load control or active power/frequency control model verification
12. **PRC-001-1.1 R5:** GOP must notify TOP in advance of changes in generation that could require changes to Protection Systems, and TOP must notify other TOPs of the same.
13. **PRC-005 R1, R2, R3, R4, and R5:** Generator Owner must perform, and document battery maintenance is a timely manner.
14. **PRC-019-2 R2:** verify coordination of voltage regulating system controls, (including in-service limiters and protection functions) with the applicable equipment capabilities and settings of the applicable Protection System
15. **PRC-024-2 R1 and ER2:** verify generator frequency and voltage protective relaying does not trip the applicable generating unit(s) within the “no trip zone” of PRC-024 Attachment 1 and Attachment 2
16. **PRC-025-2 R1:** verify generator relay settings are in accordance with PRC-025-1 – Attachment 1
17. **VAR-001-4.1 E.A. 15 and E.A. 17:** verify that generating equipment uses voltage set point, and complies with external voltage control loop specification established by these requirements
18. **VAR-002-4 (all):** comply with operation and notification requirements during testing and upon initial commercial operation

19. **VAR-002-WECC-2 R1:** have AVR in service and in automatic voltage control upon initial commercial operation
20. **VAR-501-WECC-3**: (all): comply with settings. Testing and operational requirements established by this Standard

The standards listed are subject to change and the contractor will need to communicate specific planning and timely milestones to Owner to ensure all regulatory compliance obligations are met.

Appendix M1

Attachment 01

Exhibit 09

PGE CAD AND NUMBERING STANDARDS

[Content to be provided at time of contracting]

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

REQUEST FOR PROPOSAL

NO.	DATE	REVISION	BY	CHK'D	APPROVALS	
0	15Oct21	Issued for Implementation	DNV-GL	DS	CPA	Craig Armstrong
1	14Apr23	Update from 2021 Version	PGE		CPA	Craig Armstrong

APPENDIX M1

ATTACHMENT 02

EXHIBIT 01

GENERAL CIVIL REQUIREMENTS

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

REQUEST FOR PROPOSAL

NO.	DATE	REVISION	BY	CHK'D	APPROVALS	
0	26Oct21	Issued for Implementation	1898 & Co.		JAL	Jared Lathrop
1	14Apr23	Update from 2021 Version	1898 & Co.	PGE	CPA	Craig Armstrong
2	15Dec23	Update from 14Apr23 rev	PGE	PGE	CPA	Craig Armstrong

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1.0 GEOTECHNICAL INVESTIGATION

1.1 GENERAL

The Project shall have a site-specific design level geotechnical investigation completed to evaluate subsurface conditions and provide recommendations for design and construction of all foundation systems supporting project infrastructure including but not limited to electrical collection system, electrical transmission line, substation, operation and maintenance facilities, and project civil infrastructure including roads and drainage facilities. Refer to M4-01-01 (Energy Storage Technical Documents) (the “BESS Spec”) for additional requirements applicable to energy storage projects.

The geotechnical investigation shall also include an appropriate document review of the regional geological information, including review of geological and geotechnical hazards.

1.2 DOCUMENT REVIEW

A document review shall be conducted consisting of available geotechnical and geologic documentation, which at a minimum includes the following:

1. Historical and current aerial imagery
2. Regional geologic maps
3. Soil survey reports
4. Groundwater hydrology data and maps
5. Landslide hazard maps (as applicable)
6. Karst hazard (sinkhole) maps (as applicable)
7. Mine subsidence maps (as applicable)
8. Seismic hazard maps
9. Field photographs
10. Other geologic/geotechnical hazard maps (as applicable)
11. Other applicable geotechnical and geologic mapping

1.3 GEOLOGIC/GEOTECHNICAL HAZARDS

All geologic/geotechnical hazards that may affect the project shall be included in the geotechnical study and report, with recommendations for mitigation as applicable. Geologic/geotechnical hazards shall include, at a minimum:

1. Seismic hazard and seismic effects (ground shaking, soil liquefaction, cyclic softening, earthquake induced landslide, surface fault rupture, seismic settlement, etc.)
2. Landslide and slope instability
3. Flooding and debris flow
4. Land subsidence/mining
5. Expansive soils

6. Collapsible soils
7. Corrosive soils
8. Excessive settlement
9. Karst/sinkhole hazards
10. Frost heave
11. Any other geological/geotechnical hazards that may affect the project

1.4 GEOTECHNICAL EXPLORATION

The scope of the geotechnical investigation shall be consistent with the corresponding industry standards of practice and the recommendations shall be adequate for use in design and construction of the Project. The number and depth of soil borings, as well as field testing required to confirm design assumptions and requirements, shall comply with the BESS Spec. Sufficient rock core samples shall be obtained from each boring including coring from the point at which competent rock is encountered and until the appropriate boring depth is achieved (at a minimum).

1.5 GROUNDWATER CONSIDERATIONS

Effects of groundwater shall be accounted for in the foundation design and considered in construction of the project. Monitoring of groundwater levels shall be taken over a sufficient period to capture seasonal fluctuation in groundwater levels. The geotechnical engineer shall determine the design groundwater level, which shall take into account seasonal fluctuation as well as long term groundwater levels, and shall account for any buoyancy effects resulting from the design groundwater level.

1.6 GEOTECHNICAL LABORATORY TESTING

Laboratory testing shall be conducted on samples from soil borings gathered during the subsurface exploration program to determine engineering properties for design of the proposed foundations. Laboratory testing on samples collected during the exploration program shall be sufficient to characterize all soil types and layers that may have an impact on the foundation design.

The following tests shall be included, as appropriate, in the soil laboratory testing program to support foundation design and electrical design activities:

1. Moisture content per ASTM D2216 and unit weight per ASTM D7263 (all relatively undisturbed samples).
2. Atterberg Limits per ASTM D4318.
3. Grain size analysis per ASTM D422.
4. Soil shear strength per ASTM 3080 (unconfined, triaxial, direct shear, vane shear, etc.).
5. Consolidation/settlement characteristics per ASTM D2435.
6. Compaction characteristics per ASTM D698 (maximum unit weight, optimum moisture content, etc.).

7. Hydrocollapse (as appropriate).
8. Corrosion characteristics per ASTM D4972 and USEPA methods (Sulfate, chloride, pH, resistivity, etc.).
9. Minimum resistivity.
10. Soil Thermal resistivity including dry-out curves including 0% moisture per ASTM D5334. Quantity of test sites shall depend on site plans and geology.
11. Soil Electrical resistivity using the “Wenner Four Probe Method” in accordance with ANSI/IEEE Std 81: 1983 - IEEE Guide to Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of Ground Systems. Unless otherwise approved, the probe spacing shall be equally spaced with spacings of 2 ,5, 10, 15, 20, 30, 40, 50, 80 and 100 ft. Quantity of test sites shall depend on site plans and geology.
12. Unconfined compressive strength per ASTM D2166.
13. Unconsolidated-undrained triaxial compression per ASTM D2850.
14. Other laboratory testing as appropriate.

1.7 GEOTECHNICAL ANALYSES AND RECOMMENDATIONS

Geotechnical engineering recommendations shall be provided in the geotechnical report for the following for incorporation into design of the project:

1. Foundation design parameters (including factors of safety and uplift resistance)
2. Design groundwater level and recommendations for construction dewatering
3. Earthwork recommendations, subgrade preparation, compaction requirements, final grading, and testing requirements
4. Mitigation measures for unsuitable soils (expansive soils, collapsible soils, etc.)
5. Seismic parameters in accordance with local codes and standards
6. Mitigation measures for soil corrosion of concrete and buried metal
7. Recommendations for mix design of concrete in contact with on-site soils
8. General recommendations for civil work and facilities
9. Recommendations for site drainage (slopes)
10. Recommendations for foundations supporting site buildings
11. Recommendations for substation foundations
12. Recommendations for transmission line foundations, as applicable
13. Recommendations for gravel and paved roads
14. Frost heave loading (adfreeze), if applicable
15. Trenching and backfill recommendations
16. Recommendations for earth-retaining structures (e.g., retaining walls), as required
17. Any other pertinent geotechnical recommendations for the project as identified by the Geotechnical Engineer of Record

2.0 CIVIL WORKS

The design shall suit the requirements for construction access for long loads, heavy equipment and cranes, as well as ongoing access for operation and maintenance facilities. Design and construction of civil works shall comply with agreements between Owner and local authorities, as well as between Owner and OEM Supplier, and be designed per the project requirements and OEM Supplier's project site requirements.

Site entrance, access roads, site drainage, ancillary structures, and general project layout shall follow the recommendations in the hydrology study to control storm water runoff and prevent flooding of roads, equipment inundation and erosion of soils. A hydrology study based on the storm events noted in Section 2.7 below flood inundation event shall be performed to describe the hydrology of the Site and any impacts that the hydrology may play in the design of the site layout. Drainage shall be provided by Contractor and designed to prevent flooding, inundation of equipment and erosion. Additional requirements are outlined in the BESS Spec.

All roads and tracks shall be designed in accordance with the geotechnical engineer's recommendations appropriate to the site, climatic conditions and their period of use. Treatment of cut and fill slopes and installation of drainage shall be in accordance with applicable state and local standards and regulations. All fences, gates, cattleguards, and entrances shall be in accordance with applicable standards and permits, and shall be of a standard type and similar in all aspects with the type commonly used in the local area unless otherwise specified. All fencing and gates shall comply with the requirements set forth in M1-01-07 (Security and Compliance).

Requirements for formwork, reinforcement, concrete works and batching plant, materials strength, shall be in accordance with applicable state and local codes, standards and guidelines, and shall comply with the BESS Spec.

Restoration shall be in accordance with the Permits and planning and environmental constraints on the Project. All crossings shall be in accordance with utility and county agreements.

2.1 CONCRETE WORKS AND BATCHING PLANT

Contractor shall provide a detailed method statement for quality control and concrete batching and transport.

Concrete shall be transported, placed, compacted and cured in accordance with Applicable Standards.

Concrete mix design, cement, aggregate, admixtures, and trial batch test result shall be provided for owner approval prior to concrete placement. A successful break test showing the minimum specified compressive strength(s) shall be provided prior to concrete placement.

If an on-site portable batch plant is used, the following shall apply:

1. Contractor shall provide and maintain on-Site storage of cement, aggregates and all other materials required for concrete production.
2. Contractor shall provide and maintain a concrete batching plant(s) with all equipment, facilities, approvals and permits that are required for the associated batching plant(s).
3. Contractor shall remove from plant from site within 30 days of final concrete pour utilizing plant.

If an off-site batch plant is utilized, the following shall apply:

1. Travel times to the primary and backup batch plants shall be provided for owner approval
2. A transportation plan for off-site concrete batch plants shall include an allowance for potential traffic impact on transportation time, for owner approval

A backup shall be provided for critical items including the batching plant (on site or alternate location), concrete delivery and placement equipment (conveyor belt or pump).

Prior to pouring, Contractor shall install all grounding elements and cable ducts (tapes, electrodes, etc.). Exothermic (Cadweld, etc.) welding of grounding elements to reinforcing steel shall not be permitted.

A concrete placement plan shall be prepared in accordance with a Contractor-provided mass concrete placement plan. Unformed concrete finish on the surface of the concrete shall be screeded and finished neatly to be uniform and non-slip when wet.

Adequate precautions shall be implemented in finishing to prevent plastic shrinkage cracking. Methods to be used for plastic shrinkage cracking shall be provided to Owner prior to placement of concrete.

A hot and/or cold weather concreting plan shall be prepared in accordance with ACI 305R and ACI 306R, as applicable to anticipated project site temperatures.

2.2 CONCRETE AND GROUT STRENGTH

As a minimum, concrete and grout shall have a minimum 28 day compressive strength of 4000 psi, or greater as specified by the foundation designer.

Concrete constituents shall meet the requirements listed in Table 1, below:

Table 1 Concrete Material Standards

Material	Requirement
Water	Clean, Potable, free from acid/alkali, oil, petroleum products, organic material or other deleterious substances
Portland Cement	ASTM C150, Type I, II, or V or ASTM C1157, Type GU, MS, or HS
Coarse Aggregate	Gravel, crushed gravel or crushed stone, in accordance with ASTM C33
Fine Aggregate	Washed natural or manufactured sand, in accordance with ASTM C33
Concrete Curing Compound	ASTM C309 and C1315
Admixtures:	
Air Entrainment	ASTM C260
Water-reducing	ASTM C494 Type A
Retarding	ASTM C494 Type B
High Range, water reducing	ASTM C494 Type F
High range water-reducing and retarding	ASTM C494 Type G
Fly Ash	If allowed by engineer of record, fly ash may be used to replace up to 20% of cementitious material content by weight in accordance with ASTM C618 Class F; Class C fly ash shall not be used without Owner approval.

Grout materials shall be non-shrink cementitious (ASTM C1107) or epoxy material.

The concrete or and grout strength shall be defined by the characteristic compressive strength at age 28 days.

Sampling and testing of concrete shall be in accordance with ACI 318, ASTM C172, ASTM C31, ASTM C39, ASTM C172, ASTM C231, ASTM C143 and ASTM C1064.

Sampling and testing of grout material shall be in accordance with ASTM C579.

Sampling and testing concrete is be carried out by an accredited materials testing laboratory.

Maximum water/cement ratio: 0.45

Defective concrete shall be repaired by chipping out unsatisfactory material and placing new concrete.

2.3 OFF-SITE ROAD IMPROVEMENTS

Contractor shall establish any off-site road or public highway improvements that are required to:

1. Comply with agreements between Owner and the local Authorities
2. Permit full access for the project
3. Permit delivery of all plant and equipment required for the project, and
4. Permit delivery and supply of all other plant items, construction materials and equipment required to complete the Power Plant.

Contractor, with respect to the Work, shall be responsible for obtaining any relevant encroachment permits or other permits or authorizations and reaching any relevant agreements required with Government Authorities and third parties.

Contractor shall maintain off-site roads in as good or better than original condition throughout construction.

2.4 SITE ENTRANCE AND ACCESS ROADS

Contractor, with respect to the Work, shall be responsible for obtaining any relevant permits or authorizations and reaching any relevant agreements required with Government Authorities and third parties in relation to access:

1. Except where explicitly agreed as being within Owner’s scope
2. Except in the case of approvals or agreements with landowners which shall be obtained through Owner

Contractor shall be responsible for establishing the extent to which improvements are required to any existing and new site entrance and access roads to facilitate the Project.

Contractor shall be responsible for establishing the site entrance and access roads to facilitate the Work including, but not limited to:

1. Delivery and installation of Project equipment and components in accordance with the equipment manufacturer’s requirements.
2. Crane and heavy equipment access for the installation of Project components.

3. Two-way traffic for construction access
4. All-weather emergency vehicle access to work areas and site locations

Access road geometry shall conform to the following criteria, the Project component requirements, and permit requirements:

1. Road width shall be a minimum of 16 feet
2. Road cross-fall gradient shall be between 1 and 3 percent
3. Maximum road longitudinal gradient shall be 8 percent
4. Turn radii shall be as specified by the Project equipment supplier
5. Maximum vertical crest and dip on roads as specified by the Project equipment supplier.

Access roads shall be clear of overhead obstructions.

The Site entrance and access roads shall furthermore be designed to facilitate access including crane or heavy equipment access, for the ongoing operation and maintenance of the Power Plant, including turnarounds throughout the Site.

Contractor shall repair the Site roads and access roads to the design requirements at the end of the construction, but site access for crane access and delivery of large components cannot be diminished.

Particular attention shall be given to cutting, storing and reinstating topsoil and vegetation in order to encourage regeneration of vegetation.

Treatment of cut and fill slopes and installation of drainage shall be in accordance with applicable state and local standards and regulations.

All roads and tracks shall be designed in accordance with the geotechnical engineer’s recommendations appropriate to the Site, Climatic Conditions and their period of use including, but not limited to:

1. Subgrade strength
2. Hydrology
3. Flooding
4. Frost
5. Snow
6. Bearing strength

Proof rolling shall be performed on all access roads in presence of qualified, competent, practicing geotechnical engineer or qualified representative.

2.5 UNDERGROUND CABLE RUNS

Underground conduit and cable runs, including SCADA communication cables and earth conductors, shall be located at an appropriate depth to meet Applicable

Standards, Owner's requirements as set forth in the Agreement and this document, and industry best practices.

Where appropriate, conduits shall be laid during access road construction in order to avoid disturbing reinstated ground. All underground cable must be contained within conduit, except for bare grounding conductors. Direct buried cable is not allowed.

Possible surface reduction from future road maintenance shall be considered when selecting the cable burial depth at road crossings.

Cables shall be installed in accordance with Applicable Standards including requirements for mechanical protection, warning and locating tape, and depths of burial.

All trenches are to be backfilled and compacted on completion and original levels restored to a minimum level of compaction and tested as specified by the Geotechnical Engineer. No surplus soil piles or stockpiles are to be left on the Site.

Cables shall be installed via trenching; blasting and plowing are not permitted excavation methods.

Native material excavated from the trench shall be used for the bedding/cover material as much as practicable, subject to the requirements listed above, local ordinances, and the need to ensure thermal stability. All trench bedding and/or backfill materials shall be screened and visually inspected for materials in excess of two (2) inches, with any backfill within 12 inches of cable being free of sharp objects, rocks, and other debris larger than 0.5 inches. All bedding and/or backfill material shall be composed of materials that are native to the Project Site. Such materials shall be free of debris, roots, organic matter, frozen matter, coal, ashes or cinders. In areas where topsoil is present, the topsoil shall be preserved during excavation and replaced following installation of the backfill.

Reseeding shall be undertaken by Contractor once trenches are backfilled and topsoil replaced.

Variations in underground cable installation depths, due to road/creek crossings and the typically rigid structure of direct burial machines, shall be considered in the cable sizing calculations and the selection of cable depth derating factors.

Cable runs within the MV/HV substation shall be installed in precast concrete trenches and/or Schedule 40 PVC conduits with a radius not less than 60" for conduit 5" or larger, or radius not less than 36" for conduit 2-4" in diameter. Conduit size / fill ratio shall be in accordance with ANSI / NFPA 70, at a minimum.

Direct buried cables leaving a trench to pass through ground surface shall be protected by a PVC conduit bend and concrete haunch, or other rigid frame acceptable to Owner.

Contractor shall be responsible for reinstatement of all fences, walls, watercourses, roads and embankments crossed by the cables to the satisfaction of Owner and in accordance with all Applicable Permits.

Suitable cable marker posts shall be installed to indicate the route and depth of all underground power cables at each change of direction and on each side of each corresponding road or rail crossing, fence crossing, pipeline, utility crossings, property lines, wetlands, and streams.

1. The markers shall include cable voltage details and telephone numbers of both the asset Owner and the appropriate dig-safe agency.
2. Landowners shall also be provided with these phone numbers and the as-built cable route details and drawings.

Electronic cable marking tape shall be installed along the length of all buried power cable.

An appropriate cable locating device shall be provided to enable the location of underground cables, splices, and electronic markers. GPS-located marker balls are preferred for this purpose.

When fiber cables are installed in a trench, the fiber cable shall be placed in conduit, Pest Duct (required for all non-armored cable), or continuous innerduct; the fiber cable shall be rated for underground use; and there shall be a suitable locating cable installed in the innerduct/conduit. Innerduct shall have a minimum diameter of 1.25 inches. Fiber optic shall be separated from any power cables when co-located in a trench..

2.6 FENCES, GATES, ENTRANCES, CATTLEGUARDS

All fences and entrances shall be in accordance with Applicable Standards and Applicable Permits.

All fences, gates, entrances, and cattleguards shall be of a standard type and similar in all aspects with the type commonly used in the local area unless otherwise specified.

Contractor shall determine and comply with the requirements of all Government Authorities.

All fencing and gates shall comply with the requirements set forth in M1-01-07 (Security and Compliance).

2.7 DRAINAGE

Drainage shall be provided by Contractor and shall prevent erosion, consistent with:

1. Federal, state and local laws and regulations
2. The design assumptions and criteria of the foundations, and other elements of the Civil Infrastructure
3. The absolute requirement to maintain adequate soil cover over the equipment foundation
4. Pollutant discharge and other environmental permitting restrictions on construction and the finished Project
5. Consideration of the safety of personnel and wildlife through the construction work

Batters and steep slopes that are disturbed in the course of the Project shall have a suitable means of stabilization applied.

Erosion control measures shall be installed in accordance with federal, state and local standards and regulations.

Appropriate means of energy dissipation shall be incorporated into the site drainage.

Additionally, Contractor shall provide drainage that shall accommodate:

1. A 20-year 24-hour return period flood event for the road and drainage infrastructure, and
2. A 100-year 24-hour return period flood with sufficient freeboard for the Project infrastructure, substation and permanent buildings.

Drainage infrastructures shall include culverts or low-water crossings installed / constructed where required to pass existing storm water concentrated flows. Culvert pipe ends, swales, and ditches shall be designed and constructed to control concentrated flow velocities and minimize erosion and siltation.

The natural drainage patterns of the Site shall be maintained and ponding shall be prevented, other than explicitly where small scale ponding is specifically designed to minimize erosion during drainage. Any pre-existing drains which are damaged in the Work shall be restored.

Access road and crane pad drainage shall be integrated and prevent water flow on the roads. All roads and pads shall have a minimum side slope of 1% to promote drainage.

Water pooling under the inverter and step-up transformer pads (if required) shall be prevented. To comply with this requirement, Contractor shall consider raising the ground level prior to installing the transformer kiosks.

Excavations shall be fully drained prior to any construction work within them.

A hydrology study shall be performed to describe the hydrology of the Site and any impacts that the hydrology may play in the design of the site layout. Drainage shall be provided by Contractor and designed to prevent flooding and erosion, consistent with:

1. Federal, state and local standards, laws and regulations
2. Recommendations from the hydrology study
3. Pollutant discharge and other environmental permitting restrictions on construction and the finished Project
4. Consideration of the safety of personnel and wildlife through the construction work

2.8 DISPOSAL OF EXCESS MATERIAL

Surplus soil and excavated materials may be disposed of on-Site to the extent this is consistent with Applicable Permits and planning and environmental constraints on the Project.

Other wastes including chemical waste shall be removed from the Site and disposed in an appropriately registered facility in accordance with federal, state and local laws and regulations. If immediate removal is impractical the wastes are to be temporarily stored in accordance with the Laws and applicable standards.

All permits and authorizations required for the temporary storage of waste on site shall be obtained by Contractor.

No litter, unsuitable materials, or construction related waste is to be left on the Site. Contractor shall remove all waste, including that of which is generated within temporary facilities.

2.9 RECLAMATION

Contractor shall reclaim all areas which have been disturbed during the Work by replanting and indigenous seeding, including conformance with the requirements of any Permits, the SWPPP, and any Project Agreements. All Work areas shall be restored to their pre-construction condition, at a minimum.

(1) Contractor shall remove all tools, equipment, surplus materials (including unused or useless materials), waste materials, temporary work (including temporary erosion control features), temporary buildings, temporary facilities (including batch plants, rock crushers, and office trailers), and rubbish from the Site prior to final completion, and shall cause any facilities used by Contractor during the performance of the Work to be restored to the same or better condition that such facilities and the Site were in on the date the Contractor commenced work at the Site, ordinary wear and tear excepted.

(2) All drains and ditches shall be cleaned at completion of the construction Work, including removal of soil and debris from culverts, and leave the Site in a neat and presentable condition wherever construction operations have disturbed the conditions existing at the time of starting the Work.

(3) Preserve and/or restore to their pre-construction condition all land and water resources adjacent to construction areas. Such work shall include restoration of all terraces to their pre-construction condition.

(4) Notwithstanding the following paragraph (a), laydown areas (including the laydown yard), roadway shoulders, and roadway turning radii shall be decompacted and reclaimed, including proper grading, aggregate touchup, and seeding with an approved mixture. For the avoidance of doubt, such areas shall not be reclaimed until applicable erection/installation activities have been completed.

(5) Re-dress all road surfaces within the Site such that the final cross section meets the Contract specifications, including those presented herein, and such that all roadway surfaces are graded for draining and low spots are removed.

(6) Seed all cut / fill slopes utilizing an approved seed mixture. Seeding shall occur during a time / season when the probability of successful seed germination is maximized; hydro-seeding is acceptable for slopes.

(7) Fill all depressions and water pockets caused by construction operations and remove all obstructions within waterways.

(8) Spread surplus fill on-site in areas and depths approved by Owner.

(9) Spread recovered aggregate from laydown yard within approved disturbance limits at Owner-approved locations including but not limited to on access roads, and/or the operations and maintenance building yard.

(10) Collect large rocks or boulders unearthed during excavation as part of the Work but not utilized in the construction of the Project and store at an Owner-approved location at the Site.

The seed mix and plant species are to be approved by Owner prior to re-seeding.

Reclamation shall be in accordance with the Permits and planning and environmental constraints on the Project.

APPENDIX M1

ATTACHMENT 04

EXHIBIT 01

GENERAL ELECTRICAL STUDY REQUIREMENTS

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

REQUEST FOR PROPOSAL

NO.	DATE	REVISION	BY	CHK'D	APPROVALS	
0	26Oct21	Issued for Implementation	1898 & Co		JAL	Jared Lathrop
1	14Apr23	Update from 2021 Version	1898 & Co.	PGE	CPA	Craig Armstrong

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1.0 SCOPE

1.1 GENERAL

This specification covers the technical requirements for electrical system studies. The Contractor shall provide electrical system studies for the entire project, including arc flash hazard, load flow, short circuit, relay coordination, insulation coordination, DC/UPS sizing and grounding calculations.

The electrical system studies shall be prepared by the Contractor's qualified engineers or by an approved consultant. The coordination study and analysis shall be signed and sealed by a registered Professional Engineer. The Contractor is responsible for providing all pertinent information required by the preparers to complete the study.

1.2 STANDARDS AND DOCUMENTS

Calculation and documentation shall be performed in accordance with the applicable standards in M4-01-01 (Energy Storage Technical Specifications).

2.0 SOFTWARE AND MODELING REQUIREMENTS

Electrical system studies (3.1 – 3.3) shall be performed utilizing Easypower software (Contractor shall confirm acceptable software version with Owner). Systems or components considered as part of the Bulk Electric System (BES) shall be modeled using Aspen OneLiner. Examples of BES components are collector circuits, substation, and switchyard equipment. The Easypower/Aspen model shall include a complete system one line diagram with the following minimum requirements:

1. Utility source information including calculated maximum and N-1 three-phase and single line-to-ground short-circuit current values and X/R ratios.
2. Bus nodes with ampacity and voltage ratings, and available short circuit current.
3. Transformer ratings with all MVA ratings, voltage ratings on all windings, positive and zero sequence impedance ratings of each winding connection (primary-secondary, secondary-tertiary, primary-tertiary), load tap changer ratings, de-energized tap changer ratings, and inrush currents.
4. Cable and iso-phase bus size, type, impedance, and cable lengths within 10 feet of actual (through the 480 V level).
5. Circuit breaker or protective device make and model, frame ampacity, trip plug rating, and protective settings.
6. Motor circuit protectors make and model, ampacity, and protective settings.

7. Motor loads including horsepower, voltage, full load amps, and locked rotor amps.

8. Variable speed drives and protective settings.

9. Generators, including all nameplate information.

10. Neutral grounding resistor/transformer size and ratings.

11. 480 V panelboards including all branch circuit information.

12. Protective relay make, model, and protective settings.

13. DC/UPS chargers, inverter, batteries, disconnects, and panelboards.

14. 120/208 V panelboards including all branch circuit information.

15. As agreed upon by Owner, below a certain KVA, any loads fed from a single distribution panel, including aggregated power sources, can be lumped together as an individual element within the model.

16. WECC PSCAD transient model

3.0 DESIGN CALCULATIONS

3.1 ELECTRICAL STUDIES

3.1.1 Load Flow

Prepare a load flow study in Easypower to determine the steady state loading profile of the project electrical system.

Review the load flow study results and provide a listing of electrical equipment that shows overload, based on National Electrical Code loading requirements

Present the data conclusions of the load flow study in a table format. Include the following:

1. Bus identification
2. Bus nameplate ampacity
3. Operating voltage
4. Load Current

3.1.2 Reactive Power

Prepare a reactive power study to determine the reactive power capability of the project including additional reactive power compensation equipment to meet interconnection requirements as necessary to supplement site generation equipment reactive power capability, if applicable. Study shall include determination of voltage step due to capacitor switching to confirm compliance with power quality requirements including flicker. The study shall identify reactive compensation required to meet the project requirements, including the interconnection agreement requirements for power factor and voltage regulation, and including any capacitor bank and/or reactor requirements. This study shall include combinations of (a) active power (no load to full load at ten percent (10%) increments); and (b) voltage (0.95 to 1.05 pu) at the point of interconnection, or more stringent as necessary to meet project requirements, including the interconnection agreement and compliance with FERC Order 827.

A pre-construction reactive compensation study and an as-built reactive compensation study, respectively, shall be submitted.

3.1.3 Thermal Ampacity

Prepare a thermal ampacity study to determine the underground MV and LV cables are adequately sized for the worst-case load current. Study shall include modeling of all trench and bore configurations including supporting assumptions of soil rho, native or non-native backfill, temperature, and compaction.
This study shall include all medium-voltage cable and low-voltage cable (from the turbine to the pad-mounted transformer). The final report shall include a table showing cable ampacity and percent loading per cable section corresponding to the Project one-line diagram. Cable ampacity shall not cause the operating temperature of cable insulation to exceed 105C or temperature limits as specified in this study, whichever is less. All external heat sources shall be considered, including parallel circuits. Thermal design shall account for actual field soil samples, maximum ambient temperature as defined by historical weather data, and backfill requirements (native or engineered).

3.1.4 Electrical Losses

Prepare an electrical losses study to determine the total power losses and annual energy losses from generation unit to point of interconnection. This study shall be sufficient to demonstrate that the, as defined in the Contractor scope of work, is not being exceeded, and shall be based upon project-specific cabling and transformer specifications, Project site-specific soil conditions, project site-specific operating data, and other similar considerations. A pre-construction annual energy loss study and an as-built energy loss study, respectively, shall be submitted. The energy loss calculation shall include supporting assumptions and breakdown of subsystem loss contribution. The loss study shall be based on IFC drawings and be revised following construction to include any material changes to the EBoP in as-built drawings.

3.1.5 SHORT-CIRCUIT

Prepare a short-circuit study for electrical equipment provided for the project.

The Contractor shall request from the Owner the available fault ratings of the source utility connection. The Owner shall provide the fault ratings no later than 28 days upon receiving the request from the Contractor.

Calculate the fault impedance to determine the available short-circuit and ground fault currents at each bus. Incorporate the motor contribution in determining the momentary and interrupting ratings of the protective devices. Short circuit analysis shall be run at a collection system pre-fault voltage of nominal voltage of 105%. In addition, the report shall consider all short circuit scenarios when the bus ties are closed and when the bus ties are open. This study shall include maximum and minimum fault current results for three-phase, single phase-to-ground, phase-to-phase, and double phase-to-ground faults at each of the collection system circuits, the project substation, and the interconnection line.

Collection power cables and grounding conductors shall be sized to appropriately withstand maximum fault currents for the duration that is specified in the interconnection agreement or other requirements as provided in the scope of work contract, whichever is greater.

The short circuit study shall be utilized in Contractor’s electrical designs to support a coordination study and equipment specifications.

Fault current results in this study will also include direction fault current data which may be used in the coordination study.

Analyze the short-circuit calculations, and highlight equipment determined to be underrated regarding fault duty as specified. Propose approaches to effectively protect the underrated equipment.

Present the data conclusions of the short-circuit study in a table format. Include the following:

1. Device identification
2. Operating voltage
3. Device rating
4. Calculated short-circuit current (symmetrical and asymmetrical)

3.1.6 MOTOR STARTING STUDY (if required)

Prepare a static motor starting study for electrical equipment provided for the project. The motor starting study shall evaluate the capability of the auxiliary power system to start the largest motor load on the MV and LV systems at normal operating voltage (100%) as well as the minimum operating voltage (95%) with transformers at nominal tap.

Cases shall also be run for startup (back fed from system no generator online) and normal (generator online).

The report should confirm that the motor terminal voltage does not dip below the minimum starting motor terminal voltage of 80%.

Present the data conclusions of the Motor Starting study in a table format. Include the following:

1. Device identification
2. Operating voltage
3. Motor terminal voltage during starting

3.2 COORDINATION STUDY

The Contractor shall provide a selective coordination study using either Easypower or Aspen OneLiner (Easypower to be populated with Aspen OneLiner results) with an organized time-current analysis of each protective device in the project. The coordination study scope shall include protective devices including the entirety of the project substation, collection system, generators, and switchyard as applicable. This study shall provide detailed calculations, one-line and three-line diagrams, fuse curves, coordination curves, protected equipment data, and relay set points. This study shall also consider and coordinate with the interconnection utility’s reasonable requirements. A narrative philosophy statement shall be submitted for comment before completing the coordination study and the proposed settings shall be shared with relevant stakeholders (e.g., OEM) for implementation prior to energization. Contractor shall be responsible for obtaining approval from the utility for the proposed relay settings and coordination with the Utility’s protection and control scheme.

The coordination study shall consider maximum and minimum fault current results as determined by the short circuit study.

Contractor shall communicate with the interconnecting switchyard/substation owner to coordinate remote-end line relay settings between the interconnecting switchyard/substation and the project substation.

Prepare the coordination curves to determine the required settings of protective devices to ensure selective coordination. Graphically illustrate on log-log paper that adequate time separation exists between series devices, including the utility company upstream device. Plot the specific time-current characteristics of each protective device in such a manner that upstream devices are clearly depicted on one sheet.

After developing the coordination curves, highlight areas lacking protective coordination. Present a technical evaluation with a discussion of the logical compromises for best coordination.

The following information shall also be provided on the time coordination curves:

1. Device identification
2. Voltage and current ratio for curves
3. 3-phase and 1-phase ANSI damage points for each transformer
4. Transformer inrush points
5. No-damage, melting, and clearing curves for fuses
6. Cable damage curves
7. Maximum short-circuit cutoff point
8. Minimum short-circuit cutoff point

Develop a table to summarize the settings for the protective devices. Include the following in the table:

1. Device identification
2. Relay CT ratios, tap, time dial, and instantaneous pickup
3. Circuit breaker sensor rating, and all protective elements as specified in the protection and control drawings
4. Fuse rating and type

3.3 ARC FLASH HAZARD STUDY

An arc flash hazard analysis shall determine the arc flash boundary, the incident energy at the working distance, and personal protective equipment that people within the arc flash boundary shall use. These results shall be provided for all reasonably operated enclosures and corresponding buses at major substation equipment, collection system, transformers (including pad-mounted), switchgear (as applicable), operations and maintenance building, and other major components, as applicable.

The Contractor shall perform an Arch Flash Hazard Study in Easypower as identified and in accordance with IEEE 1584. The following modeling requirements shall apply:

- In addition to IEEE 1584 recommended scenarios, scenarios shall include maintenance mode selection of switchgear protective relays.

- As identified in NPFA 70E Article 130 the Arc Flash Boundary shall be the distance at which the incident energy equals 5 J/cm2 (1.2 cal/cm2).

Develop a report to summarize the arc flash hazard information at electrical equipment rated 120 volts or greater. The report shall provide the following information for each piece of electrical equipment:

1. Available incident energy and the corresponding working distance

2. Minimum required level of PPE to meet incident energy calculations

3. Highest Hazard/Risk Category (HRC) for the equipment

4. Nominal system voltage

5. Arc flash boundary

6. Electrode configuration used to determine arc flash results

3.4 INSULATION COORDINATION

The Contractor shall provide an insulation coordination study to ensure the insulation coordination requirements of IEEE C62.22 have been satisfied within the project's electrical design, including proper application of surge arresters to safeguard electric power equipment within the collection system circuits, substation, and interconnection line against hazards of abnormally high voltage surges of various origins. This study shall also confirm any system modifications required to adequately limit transient overvoltage on the collection system circuits, including determination of the transient overvoltage levels on the collection system circuits after feeders have been isolated from the project substation due to a line-to-ground fault or lightning strike, and determination of the maximum energy required to be absorbed by each surge arrester on the collection system circuit feeders Contractor shall provide calculations which verify that each equipment's basic insulation level, basic switching impulse level, and chopped wave withstand rating are acceptable. Contractor shall also provide protective ratio calculations and verify that insulation coordination has been met as defined in the most recent revision of IEEE standard C62.22 or superseding equivalent.

3.5 TRANSFORMER SIZING

Transformer sizing calculations, including medium-voltage and main power transformers, shall be provided prior to procurement of any power transformer.

3.6 DC/UPS SIZING

A DC and UPS sizing calculation shall be provided to verify that the DC and UPS systems are adequately sized for the project. The Contractor shall provide the initial calculation prior to procurement of the equipment. The supplier of the equipment shall also submit a battery sizing calculation to validate the project specific battery. This study shall determine if the minimum voltages are maintained as specified and required by equipment vendors. The DC system shall be sized to accommodate future loads for ultimate switchyard configuration.

The calculation shall include:

1. A UPS Load List (indicating a load factor and diversity factor)

2. A DC Load Cycle

3. A battery sizing calculation per IEEE 485 (including 10% design margin and 125% aging factor)

4. Battery Charger sizing calculation

3.7 GROUNDING CALCULATION

Grounding calculations shall confirm that the grounding systems be provided at the substation and each generation location to assure that a person in the vicinity of grounded facilities is not exposed to the danger of critical electric shock. The grounding calculations shall be performed in CDEGS software and provided to Owner for review. The calculations must establish:

1. Touch and step potentials are within tolerable safe limits in accordance with IEEE 80.

2. Ground grid resistance is low enough to limit the ground potential rise (GPR).

In addition to IEEE 80 recommended practices, the following requirements shall be followed:

1. Most conservative body weight shall be assumed (50 kg).

2. A minimum of 3000 Ohm-meter surface rock to be installed. Surface rock to be 4” in depth with an appropriately compacted base later of ¾” minus and no felt separating the layers.

3. As-built crushed rock depth shall be recorded and updated in the calculation.

CDEGS software shall conform to the following:

1. Software Version: Contractor shall verify acceptable version with Owner.

2. Multi-layer soil model in RESAP

3. Grounding Plan in SESCAD

4. Step and Touch Potentials in MALZ

5. This study shall consider clearing time in the event of a breaker failure for the purpose of determining if the grounding design (e.g., ground potential rise) is acceptable.

3.8 HARMONICS STUDY (if required)

A harmonics study shall confirm that the generation plant harmonics output does not exceed limits required by generator interconnection requirements and IEEE 519. This study shall provide recommendations for the use of harmonic filters, equipment, and methods as necessary to meet these requirements. A pre-construction harmonic analysis report (performed at 90 percent design) and an as-built harmonic analysis report, respectively, shall be submitted.

3.9 SUBSYNCHRONOUS RESONANCE STUDY (IF REQUIRED)

A subsynchronous resonance study shall confirm no subsynchronous resonance issues or mitigation is required. EMTP software shall be used (Owner to approve software version).

3.10 EFFECTIVELY GROUNDED STUDY

An effectively grounded study shall confirm that the project is considered effectively grounded, as defined in IEEE C62.92.1.

3.11 AUXILIARY POWER STUDY

Substation AC System Study: calculation of the capacity of the low-voltage AC systems in the Project Substation to determine size of station service.

3.12 BUS STRUCTURAL ANALYSIS STUDY

A substation bus structural analysis study shall confirm that the structural design in the project substation including bus, insulators, bus structures, and foundations, and based upon the most stringent combination of wind, fault current, and ice load factors, as defined in the applicable standards and other applicable requirements are acceptable.

3.13 SUBSTATION BUS DESIGN STUDY

A substation bus design study shall perform an analysis of the buses, disconnect switches, and separately mounted current transformers within the project substation to confirm that the ampacity, structural integrity, vibration, and required mechanical and electrical ratings are in accordance with the methods and recommendations of IEEE 605. Bus design, including gust factor, exposure height factor, importance factor, and corona considerations, shall be in accordance with the procedures and data given in IEEE 605.

3.14 SUBSTATION LIGHTNING STUDY

This study shall provide direct stroke protection analysis for lightning at the project substation based upon project site-specific determinations for thunderstorm days, thunderstorm duration, isokeraunic levels, exposure, and other similar factors. The direct stroke protection system design shall include analysis using (a) the rolling sphere method of the electrogeometric model given in IEEE 998 for high-side equipment and (b) the fixed angle method for low-side equipment. The direct stroke protection system design shall be in accordance with the procedures, data, and methods given in IEEE 998.

3.15 SUBSTATION LIGHTING STUDY

This study shall provide lighting illumination calculations for the project substation to determine the illumination levels within the new substation that will be achieved with added luminaries.

3.16 FIELD EFFECT STUDY

Provide Field Effect study for transmission line. Calculations shall be made for measurement heights of 1 meter above ground surface in areas accessible to the public, within the ROW. Electric Field Strength shall be calculated for the line voltage as well as any under build. Magnetic Field Strength shall be calculated at full rated ampacity, with balanced phase currents.

4.0 NERC COMPLIANCE

The project shall be designed to comply with all applicable NERC requirements, including provision of the studies set forth in M1-01-07. Studies shall be completed prior to synchronizing. Contractor shall provide models for studies as listed in subsections c, d, e, f, and g prior to synchronizing, but these models will be verified during project commissioning.

5.0 REPORTS AND DELIVERABLES

5.1 APPROVAL REPORTS AND SOFTWARE FILES

The Contractor study preparer shall analyze the electrical system studies, prepare, and submit an approval report for each study that is required. Each report shall include executive summary, assumptions, methodology, analysis, and conclusion sections. Analysis sections shall summarize the results of each study and reports any deficiencies found with suggested corrections that should be made. Each report shall be submitted with the native software files and any referenced files for the Owners use in reviewing.

The Contractor shall provide Owner completed study reports for approval prior to proceeding with study results in accordance with Appendix M1 Attachment 01 Exhibit 02 – Engineering Documents, Drawings & Other Deliverables.

One month prior to construction completion, the Contractor shall provide the Owner two hard copies and two electronic copies of the completed electrical system as-built studies, including native software files, in accordance with Appendix M1 Attachment 01 Exhibit 02 – Engineering Documents, Drawings & Other Deliverables. The Owner shall be given 14 days to review the as-built electrical system studies and software files and provide review comments to the Contractor.

5.2 FINAL REPORTS AND SOFTWARE FILES

Upon receipt of the Owner's review comments, the Contractor shall incorporate comments into a final electrical system study report.

For the coordination study, after commissioning is complete, the Contractor shall verify the study protective device settings corresponding to the device settings in the field and resolve any conflicts.

The Contractor shall provide the Owner two hard copies and two electronic copies of the final electrical system studies in accordance with Appendix M1 Attachment 01 Exhibit 02 – Engineering Documents, Drawings & Other Deliverables. The Contractor shall also provide the Owner with a copy of the native data files for their use. Native data files for generation facilities shall include:

1. Detailed Load Flow / Dynamic (RMS) Model: PSLF or PSS/e model of the entire facility
2. Detailed Transient Stability Model: PSCAD model of the entire facility
3. Aggregate Load Flow / Dynamic (RMS) Model: PSLF model from NERC testing would satisfy this requirement

Appendix M1

Attachment 04

Exhibit 02

General Transformer Specification

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

REQUEST FOR PROPOSAL

NO.	DATE	REVISION	BY	CHK'D	APPROVALS	
0	26Oct21	Issued for Implementation	1898 & Co		JAL	Jared Lathrop
1	14Apr23	Update from 2021 Version	1898 & Co	PGE	CPA	Craig Armstrong

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1 Scope of Work

1.1 Description

This specification covers the general design, construction, and operating requirements for oil-immersed outdoor station type power transformers including solar/wind substation Generator Step Up (GSU) transformers.

Manufacturer shall provide Owner with a manufacturing schedule that includes an anticipated beginning date, end date, and duration in terms of calendar days for the following deliverables:

- Purchase of materials
- Drawings including submittal and approval processes
- Production including core, coil, tank, and connection assembly
- Final assembly including the vapor phase process, a pretanking inspection
- Factory acceptance testing
- Shipment and delivery to the substation site/storage

1.2 Design Requirements

Transformer cooling shall be ONAN/ONAF/ONAF at 55 degrees C rise on a 50 C ambient.

The transformer specified herein shall be designed, manufactured, and tested in accordance with all applicable regulations, codes, IEEE including IEEE C57.12.00 and IEEE C57.12.90, and NEMA standards, except as otherwise required by this specification.

The transformer shall be designed to comply with all elevation requirements, including corrective calculations which consider elevation in IEEE C57.12.90.

The transformer shall be designed to have impedance ratings as defined in the transformer supply agreement and corresponding data sheets. Transformer impedance ratings will comply with the ANSI standard tolerance of +/- 7.5% of guaranteed impedance ratings.

Transformer high-voltage to low-voltage winding angular displacement shall be zero degrees.

Noise level shall comply with NEMA standards and shall not exceed requirements as set forth in ANSI C57.12.00 when energized at rated voltage, rated frequency, and when carrying no load.

The manufacturer's proposal shall list any additional standards, and codes the manufacturer intends to invoke in the performance of the requirements of this specification.

Control wiring and alarms shall be in accordance with PGE Design Masters (see drawings that will be provided as an Addendum or upon request). Current versions of Design Masters shall be requested by the manufacturer prior to starting design of transformer.

1.3 Inspection

Manufacturer shall give Contractor/Owner two months advance notice of the following hold points so that a Contractor/Owner representative may be present.

Design Review

Core and coil nesting

Pre-tanking

Factory acceptance testing

Design review drawings shall be submitted for approval, 3 weeks prior to the design review meeting or as otherwise noted. The design review submittal shall include, but is not limited to the following:

1. General Outline Drawings
2. Component Outline Drawings (including bushing and surge arresters)
3. Transformer Nameplate Drawings
4. Current Transformer Magnetization and Correction Ratio Curves
5. Current Transformer Connection Drawings
6. Control Schematic and Wiring Diagrams
    a. Wiring diagrams shall show all external connections to be made by Contractor
    b. Wiring diagrams shall show all internal wiring connections made by the manufacturer
    c. Wiring diagrams shall be “point to point” wiring
    d. Drawing shall show operating voltage and current ratings of fuses and circuit breakers
7. Control Cabinet Arrangement and Connection Drawings
8. Detailed Test Plan listing all tests in sequence
9. List of all transformer parts to be shipped including spare parts
10. Short-circuit test data as described in the section 4.4(A) of this specification

1.4 Shipping

All bushings, surge arresters, and radiators shall be removed from the transformer prior to shipment. The openings left in the transformer tank from their removal shall be covered with metal plates for shipment. Transformer shipping should follow IEEE C57.150 (Transformer Transportation).

If the transformer tank is to be shipped filled with oil, it shall be covered with a nitrogen gas blanket.

Positive pressure of nitrogen gas shall be maintained between 1 psi to 5 psi at all times during shipment.

If the transformer tank is to be shipped without oil, the tank shall be filled with dry air.

Positive pressure of dry air shall be maintained between 1 psi to 5 psi at all times during shipment.

Manufacturer shall provide dew point at time of shipment.

Bushings shall be marked with the corresponding winding that they were used for during testing.

Rail, ship, or truck shipping methods are acceptable. Transformer Center of Gravity (COG) should be clearly indicated using appropriate symbols. At least two functional impact recorders and GPS locator shall be installed on transformer. Rail car shall be equipped with end-of-car hydraulic cushioning devices, GPS locator and impact detector. If shipped by rail, “Do Not Hump” signage shall be attached to rail car.

1.5 Storage

Storage during/after shipping, and before installation shall be in accordance with IEEE C57.150, manufacturer’s written requirements/recommendations, and with manufacturers approval of conditions and maintenance, including confirmation of no impact to warranty. Storage measures will include oil fill and dry nitrogen blanket (for long storage durations – nitrogen pressure to be between 1 psi to 5 psi), power to control panel heater, and periodic inspection and gauge readings, all in accordance with manufacturer requirements and approval. Unassembled components shall be stored in accordance with manufacturer requirements/recommendations, in original shipping containers, and protected from weather.

1.6 Reference Standards

This equipment shall be built and tested in accordance with the applicable standards and its supplements listed in M2-01-01 (Wind Plant Specifications) (the “Wind Spec”), M3-01-01 (Solar Photovoltaic Plant Specifications) (the “Solar Spec”), and M4-01-01 (Energy Storage Technical Specifications) (the “BESS Spec”), as applicable.

2 Materials

2.1 General

Materials and components shall be new, undamaged and shall conform to pertinent NEMA and IEEE standard specifications and the following requirements.

All components and parts shall be readily available in the United States. All components shall be readily identifiable by manufacturer's name and part number.

Metric sizes are not acceptable.

2.2 Core and Windings

Contractor shall specify the winding ratings for each terminal designation, including the voltage rating, continuous current rating, BIL rating, and catalog number. BIL ratings shall be determined as per IEEE C57.12.00.

Except for pad-mount transformers, all windings shall be copper. Aluminum windings may be used pad-mount transformers only.

All windings shall be insulated with thermally upgraded paper and verified with long-duration test per IEEE C57.100.

Where applicable Netting Continuously Transposed Cable (CTC), Epoxy Bonded, is preferred.

All windings, except tertiary winding, shall have a through-circuit capacity MVA rating at a 60°C rise, of the max MVA rating of the transformer.

The average winding temperature rise shall not exceed 60°C above ambient (a maximum 30°C average 24-hour ambient, and a 45°C maximum ambient).

The maximum hottest-spot winding temperature rise shall not exceed 80°C rise over ambient (110°C continuous with 30°C ambient, 120°C short-term emergency rating with 40°C ambient).

The hottest-spot of the interior of the core should never exceed 85°C rise over ambient (125°C at 45°C ambient) to avoid gassing, and the core surface temperature must not exceed the thermal capability of the insulation or parts touching the core.

Tertiary windings (if required) shall be a delta connected stabilizing winding, and be self-protecting for short circuits at all bushing terminals. Refer to the detailed specification to determine if tertiary should be buried or brought out. Tertiary windings shall have a kVA capacity of no less than 35% of the transformer's ONAN rating.

1. Tertiary windings that are brought out may be used for station service.
2. Assume no system impedance for short circuit calculations.

3. Tertiary windings that are buried shall be designed with provisions to have the tertiary be brought out only for factory testing.
4. Tertiary winds that are buried shall have one corner of the delta brought out with two leads, from adjacent legs. These leads shall be bonded and grounded externally.

The transformer shall be designed with impedances sufficient to make the transformer self-protecting. Manufacturer shall assume that the transformer will be operated from an infinite bus.

Nuts, bolts, and clamps of the core assembly shall be provided with positive locking devices to prevent loosening caused by vibration or change of shape or position during transportation or operation. The complete core and winding assembly shall be removable from the tank for repairs.

Nomex insulation shall be used between the core and clamping structure.

For GSU's only: fiber optic temperature probes shall be installed, and provisions shall be made for monitoring system as noted below.

1. Monitoring system and sensors shall be LumaSense Technologies QualiTROL 408-12 or Owner approved equivalent.
2. Location of sensors - Fiber optic probes shall be located at the hottest winding spots as determined by manufacturer's calculations.
3. Number of sensors - Install two in each winding (for example in case of three-phase three-winding (primary, secondary, and tertiary) GSU, each winding shall have six sensors)
4. All fiber optic temperature probes shall be connected through a tank penetration box with tank wall feed-through with proper identification. (Phase, winding, Probe 1 or 2, etc.…).
5. The fiber optic tank penetration box shall be mounted on upper tank wall.

2.3 Bushings

Contractor shall specify the bushing ratings for each terminal designation, including the voltage rating, continuous current rating, BIL rating, and catalog number. BIL ratings shall be determined from the insulation coordination study as specified in the Wind Spec, the Solar Spec, the BESS Spec, or M1-04-01 (General Electrical Study Requirements) as applicable and shall meet applicable requirements in the following standards: IEEE C57.12.00, ANSI C57.19.01, ANSI 21, ANSI 24, and ANSI C57.12.10.

Acceptable manufacturers for the bushings are provided in the Wind Spec, the Solar Spec, and the BESS Spec, as applicable.

All bushings shall be bolted on.

The bushing color shall be ANSI 70 (light gray).

Bushings shall be resin impregnated synthetic (RIS) condenser capacitive graded type and shall contain no oil.

RIS bushings shall be supplied with an air-side insulator with HTV silicone rubber adhered directly to the RIS condenser body having low stress teardrop tip and no visible parting lines.

If bushings are mounted at an angle other than vertical, the angle shall not exceed 30 degrees. The bushings shall be mounted so as to provide maximum clearance to the isolated phase bus enclosure, if applicable.

All standard routine tests as prescribed by ANSI/IEEE C57.19.00 shall be performed on every bushing at levels and requirements equal to or better than specified in ANSI/IEEE C57.19.01 for oil impregnated paper bushings.

HV bushing top terminal shall conform to the requirements of IEEE Standard C57.19.01.

Bushings 35 kV and lower shall have the 200 kV BIL rating as defined in IEEE Standard C57.19.01.

Bushings shall have 20% current margin over transformer winding rating at full load with maximum cooling.

Bushings to be attached to bus duct shall be rated to 125°C hot spot temperature with no additional loss of life.

The manufacturer shall not provide bushing terminal connectors.

Bushings with bolted bottom connections shall have spade connectors with NEMA hole spacing, through bolts, and nuts. Bolted connections shall have a minimum of 4 bolts per connection.

The neutral bushing shall be identical to low voltage line bushings if voltage ratings are the same.

The neutral bushing shall be connected to a ground pad near the base of the transformer using a continuous conductor of not less than 250-kcmil flexible copper cable or equivalent flat copper bar.

Bushing monitors may be included as a line-item option.

2.4 Surge Arresters

Manufacturer shall supply metal-oxide type surge arresters for all high-voltage bushings, low-voltage bushings, and for the high-voltage and low-voltage neutrals.

Contractor shall specify the surge arrester ratings, including the duty cycle rating (station class), MCOV rating, manufacturer, type, and catalog number for each terminal designation.

A ground loop shall be furnished, of not less than 250-kcmil flexible copper cable, which is connected from one ground pad on one side of the transformer through the three low voltage arrester ground terminals to another ground pad on the opposite side of the transformer. Also, similar separate ground loops shall be provided for the high voltage and tertiary surge arresters.

Arresters shall be mounted so that the spacing between the energized end of the arrestor and the top of the in-phase bushing is no less than half the minimum recommended phase to ground clearance for the selected arrestor. Furthermore, the spacing between the grounded end of the arrester and bottom of the in-phase bushing shall be no less the minimum recommended phase to ground clearance for the selected arrester.

2.5 Instrument Transformers

A list of approved instrument transformer vendors is provided in the Wind Spec, the Solar Spec, and the BESS Spec, as applicable.

All instrument transformers shall be C800 relay accuracy per IEEE Std. C57.13.

All instrument transformers shall have a thermal rating factor (T.R.F.) of 2.0.

All current transformer leads internal to the tank shall use ETFE insulated wire with a minimum temperature rating of 150ºC.   All current transformer leads shall run the full length from the current transformer to the CT tank wall penetration box without any splices.

All taps from all current transformer secondary windings shall be connected to short-circuiting type terminal blocks located in the control cabinet.

Bushing current transformer wiring shall be a minimum of stranded No. 12 AWG, copper, terminating on ring-type terminals.

2.6 Control Cabinet

The main control cabinet shall house cooling equipment controls, electronic transformer monitor, relays, meters, test switches, indicating lights, manual control equipment, and terminal blocks.

Main control cabinet and any auxiliary control cabinets shall be a non-condensing, weatherproof, metal enclosure mounted on transformer.

The middle of the cabinet(s) shall be approximately 5 feet vertically from transformer base for easy access.

Cabinet shall be no smaller than 6 feet wide and 5 feet tall.

Cabinet shall have a minimum of two doors which shall each have:

1. A handle connected to a three-point latch to provide ease of opening and closing.

2. Door stops to hold door in "open" position. Door stops shall not interfere with opening the relay and control panel.
3. Provisions for padlocking in the “closed” position.
4. A small, clear, tempered glass window with a UV-proof coating and an aluminum hinged cover that can be lifted for viewing the transformer monitor display. Alternatively, the transformer monitor may be mounted on a swing-panel inside the control cabinet.

Cabinets shall be ventilated to avoid temperature extremes that may damage any of the contents.

Conduit entrance plate shall be removable from inside the cabinet.

Cabinets & Panels shall be configured to provide easy access to all components and their wiring during installation, testing, and maintenance.

Mounting devices on the cabinet ceiling and bottom is not acceptable.

If panel mounted equipment is used, the panels shall be hinged to swing-out for convenient access to all wiring.

Provide pockets to hold drawings and instruction books inside the control cabinet doors.

2.7 Electrical Items

Control cabinet design shall follow requirements of IEEE C57.148 and the following:

1. Interior illumination with on-off switch activated by cabinet door shall be installed on the ceiling of the control cabinet. The interior lighting shall illuminate the front of the swing panel in addition to the rest of the cabinet. A minimum of two cabinet lights with 800 lumens or more shall be installed.
2. As a minimum, a 200 watt positive temperature coefficient heater, with fan, for 120-volt AC operation shall be installed. The manufacturer shall determine if more than one 200 watt heater is required.
3. One exterior-rated 120-volt AC duplex, 20-amp, three-wire grounding-type GFI receptacle shall be installed on the exterior of the control cabinet.
4. Two interior 120-volt AC duplex, 20-amp, three-wire grounding-type GFI receptacle shall be installed inside the control cabinet.

Control cabinet instrument transformers shall follow requirements of IEEE C57.13.

Multi-breaker overload protection shall be provided for items 1, 2, 3 & 4 above.

Separate breaker overload protection shall be provided for each monitoring device: the transformer monitor, dissolved gas & moisture monitor, and bushing monitor.

Manufacturer shall supply a spare one-pole 120-volt, 20-amp breaker for use by Contractor and PGE.

All Contractor external connections for power sources, relays, alarm, and trip circuits shall be wired to terminal blocks and clearly labeled.

Manufacturer shall provide 20% spare open/unused terminal blocks for Contractor's and PGE's future use.

Any spare or unused contacts of any device used shall be connected to terminal blocks for Contractor's and PGE's future use.

Indicating lights shall have LED type displays with appropriately sized resistors in series for 125-volt DC operation. Lights shall be compatible with ET-16 lamps.

All DC circuits shall operate from an ungrounded 125V DC source. All DC equipment, including relays and alarm controls, shall be suitable for continuous operation over a range of 102-140 volt for 125V DC source.

Any device capable of producing a surge voltage in control or alarm circuits shall be furnished with surge suppressors to limit the surge voltage. Properly rated MOVs are to be applied on the AC coils. Properly rated diodes are to be applied on the DC coils.

All equipment rated 600 volts and less shall have a dielectric withstand capability of a minimum of 2500 volts, as described in IEEE Standard C37.90. Should such voltage level exceed the capability of the equipment, means shall be provided as a part of the device to protect the device against damage by voltage in excess of its withstand capability.

All lugs used for any internal compartment wiring will be of the non-insulated ring type. The indent mark from the indent tool must be clearly visible.

All control terminations made to be modular compression terminal blocks or device terminals shall be made using bare tin-plated copper ferrules. The indent mark from the compression tool shall be clearly visible.

All wiring shall be stranded, No. 14 AWG, or larger, unless otherwise specified.

All PLC and transformer monitor input (analog and discrete) wiring shall be stranded, No. 18 AWG.

Device grounds and neutrals shall be directly connected to neutral and ground buses and shall not be daisy-chained through other devices between taps.

All operating controls and indicators accessed by operating personnel in the normal operation and testing of equipment shall be located such that personnel are not unnecessarily exposed to live parts.

All circuits to the control cabinet shall be routed through flexible seal tight conduit. Conduit penetrations into control cabinet shall be conduit hubs for sealing. (Lock nuts with RTV are not acceptable.) Conduit penetrations shall only be made in the side wall of the cabinet.

2.8 De-energized Tap-changing Equipment (DETC)

The DETC shall not limit the loading of the transformer and shall be capable of a loading that is 150% of the maximum current rating.
DETC shall be furnished to provide plus and minus 5 percent adjustment of the high-voltage winding voltage in 2 ½ percent steps with 2 steps above and 2 steps below rated high voltage.
DETC shall have an external operating mechanism with provisions for pad-locking in each position. The mechanism shall be easily accessible to personnel standing on the transformer foundation.
The tap position indicator shall use the letters A, B, C, D, and E, where “A” is the setting with the highest voltage magnitude, “C” is the center tap, and “E” is the setting with the lowest voltage magnitude.

2.9 Energized Tap Changer (OLTC)

When specified by the transformer supply agreement or by data sheet, a load tap changer shall be provided per the requirements of this section.

1. Design in accordance with ANSI C57.12.10 and project-specific transformer data sheets.
2. Load tap changing equipment shall be housed in a separate compartment mounted on the main transformer tank designed to prevent any interchange of oil between the compartment and the tank.
3. Equipment for the manual control of the tap changing equipment shall be furnished in a weatherproof compartment mounted adjacent to the tap changing equipment compartment in a location to allow access and operation from the ground.
4. The tap changer shall have full rated kVA on taps up to 110% of the rated voltage and a current rating corresponding to the full load current at rated voltage on taps below rated voltage.
5. When specified to be designed for parallel operation, all equipment required for control of the load tap changer using the circulating current method of control shall be provided. This equipment shall include a selector switch for selecting parallel or individual operation, all required paralleling reactors and current transformers, and an overcurrent relay with two circuit closing contacts for remote alarms.
6. The OLTC shall be designed for 500,000 electrical and mechanical operations before vacuum bottle or contact replacement is necessary to maintain normal operation.

7. The tap changer shall be completely wired and shall include the following features:
    a. Voltage testing terminals
    b. All required current transformers.
    c. "Remote-Local" control switch.
    d. "Raise-Lower" control switch for local control.
    e. Provisions to operate tap changer by hand. Interlock shall be provided to prevent operation by electrical controls when hand operation is being performed
    f. Limit switches and stops for full raise and full lower positions and for preventing over travel.
    g. Adjustable time delay to provide sufficient delay in the first step of a raise or lower tap change.
    h. Operations counter.
    i. Space heater, lamp, and GFI-protected convenience receptacle in control cabinet.
    j. Tap position indicator mounted on the tap changer compartment.
    k. Tap position transducer with 4-20 mA output proportional to tap position.
    l. Tap position transmitter shall be compatible with remote tap position indicator provided by transformer vendor.
    m. Any additional equipment required for manual operation from either the transformer or a remote location.

2.10 Auxiliary Power Source

Contractor will provide the following power sources:

1. Two (2) 480 volt AC, three phase, 60 hertz, three-wire grounded sources
2. 125 volt DC, ungrounded two-wire source.
3. The manufacturer shall provide main Multi breaker disconnecting devices for the power sources described above.

Manufacturer shall supply automatic transfer equipment to transfer to an alternate source upon loss of the normal source. An alarm contact shall be provided to indicate a transfer to the alternate source.

2.11 Oil and Oil Preservation System

The transformer oil shall be provided by the transformer manufacturer.

If the transformer is to be supplied with oil, the oil shall be new Type II inhibited transformer mineral oil that meets ASTM D3487.

Oil used in testing or supplied with transformer or furnished in components, such as bushings, shall contain less than 1-ppm of PCB.

All oil used or furnished with the transformer and used during factory acceptance testing shall meet ASTM Standard D1275 Modified (b), Standard Test Method for Corrosive Sulfur in Electrical Insulating Oils.

A conservator tank oil preservation system shall be used. The transformer shall include the following:

1. Oil expansion tank (OET) of the conservator system shall be capable of withstanding full vacuum.
2. There shall be no air contact with oil in the OET. This shall be accomplished by a nitrile air cell (diaphragm not allowed) vented to the outside air through a dehydrating breather. The breather shall be installed at eye level to allow for access without a ladder. Acceptable dehydrating breather manufacturers shall be Messko MTraB. The use of other manufacturers is subject to Owner approval.
3. Air cell shall be designed for flange installation; clamps not allowed.
4. A sealed entry into the air cell shall be provided to permit calibration of the oil level gauge.
5. Each end of the OET shall have sealed entry ports to adjust the bladder.
6. OET shall be of sufficient volume to operate through an ambient temperature range of minus 29°C to plus 43°C without causing a low-oil-level alarm or exceeding recommended full-oil level upper limit.
7. Two SHUT-OFF VALVES shall be provided in the oil line between OET and main tank. One at the entry point to the OET capable of holding full head of oil in OET, one at entry to main tank that will hold under full vacuum on the main tank.
8. Piping shall be provided between the oil and air space of the OET to equalize the pressure on both sides of the air cell during vacuum oil filling. A vacuum-proof valve shall be installed at the highest practical point on the oil expansion tank (OET) to isolate the two areas after the operation is completed.

2.12 Gasketed Joints

Nitrile (BUNA-N) elastomer gaskets shall be used to make pressure tight joints on the oil filled transformer. Gaskets made of cork-only or neoprene-only are not acceptable.

Gaskets that are not continuous shall be “vulcanized joint nitrile gaskets” and not have a butt or scarf joint.

O-ring gaskets are preferred for bushing flanges and manhole covers.

Flanges shall be provided with mechanical stops or grooves to prevent over compression of gasket when tightened.

Joints shall be designed so that gasket material will not be exposed to the weather.

2.13 Tank

The manufacturer shall provide the following on the transformer tank:

1. The transformer shall be single-tank.
2. At least two manhole covers for transformer inspection; they shall be 24 inches or larger in diameter and shall be bolted. Additional access manholes may be requested for larger transformers.
3. Radiator valves at inlets and outlets of tank to permit removal of radiators without draining oil from tank.
    a. Radiators shall have at least one lifting eye, a vent plug in the top header, and a drain plug in the bottom header.
    b. No gasketed joints are allowed between the valves and the tank.
    c. Valves shall provide minimum restriction of oil flow.
    d. Valves shall be lockable butterfly type valves. Flapper type valves are not allowed.
    e. Paint shall not interfere with the operation of valves.
4. Two-inch lower oil-drain globe-type valve with oil sampling device provided on discharge side of valve. Valve shall allow essentially full drainage.
5. Two-inch upper oil-fill globe-type valve connection.
6. An external 1-in, pipe shall be provided between the tap changer compartment and the main tank located not more than 3 in. below the top of each compartment. A 1-in, ball valve shall be installed for manifolding between the two tanks.
7. Core ground leads shall be brought out of the main transformer tank wall through an insulated, porcelain bushing, and connected to a separate grounding pad at an external location.

   a. Grounding pad shall be identified and located within 6 feet of the transformer base.
   b. A protective cover shall be provided for the core ground bushing.

8. Five grounding pads with tapped holes (NEMA 2-hole Standard); one on each corner of the transformer base, and one for the core-ground leads detachable connector.
9. If tank ribs are used for expansion space, permanent labels, noted in 3.3 (B.3) shall be attached to each rib that it is pressurized. Tank weld seams inside pressurized ribs shall be avoided. Drain plugs shall be provided for pressurized ribs.
10. Tank weld seams that are behind tank ribs shall have an inspection plug installed to verify weld integrity.
11. The entire interior of the transformer tank shall be primed white with a primer that will not affect the electrical characteristics of the oil.
12. Provide one-inch valve approximately one foot above oil drain valve for connection of an air supplier during maintenance. Valve shall be plugged with a removable plug.
13. Gas sampling valve to vent gasses from transformer tank or gas accumulation relay.
14. Seven dry thermometer wells shall be installed in the main tank for specified or future thermal devices, to be used as follows:
    a. Dial-type Top Oil Thermometer.
    b. Top Oil Temperature (for transformer monitor)
    c. Top Oil Spare.
    d. Top Oil by Radiator Header Pipe (spare)
    e. Bottom Oil by Radiator Header Pipe (for transformer monitor).
    f. Dial-type Winding Temperature Thermometer
15. Spare thermometer wells shall contain a removable metal plug incapable of corrosion (brass, stainless steel, etc.).
16. The high voltage bushing H2 shall be on the same centerline as the low voltage bushing X2 (not necessarily on the tank centerline).
17. Low voltage and tertiary bushings that are external to the tank shall be spaced no less than 30 inches center-to-center.

2.14 Cooling Equipment

2.14.1 Fan Motors

1. A list of approved fan manufacturers is provided in the Wind Spec, the Solar Spec, and the BESS Spec, as applicable.
2. Cooling fans shall be rated 60 Hz and 115/230Vac (for single-phase) or 208-230/460Vac (for three-phase).
3. Motors shall be suitable for operation in wind-driven rain. Motor bearings shall be ball-bearing, self-lubricating, sealed-type, designed for continuous as well as intermittent duty.
4. Motors shall be fitted with flexible cable terminating on self-locking, weatherproof connectors.
5. Manufacturer shall provide disconnecting devices, control switches, control relays, starting equipment with undervoltage protection, and separate overload protection for each fan motor.
6. Manufacturer shall provide Elapsed Time Meters capable of counting 99,999 hours, non-reset, to record each fan group's running time to the nearest hour.

2.14.2 Radiators

1. Heat exchangers are not to be substituted for radiators, unless otherwise specified.
2. Radiator materials shall have melting points in excess of 1000°C. Materials used for welding or brazing the radiators shall also have melting points in excess of 1000°C.

2.14.3 Fan Blades

1. Fan blades shall be made of corrosion-resistant metal.
2. Fans shall have OSHA-approved safety guards.

2.14.4 Cooling Equipment Control

1. The temperature monitoring equipment described in 2.15 (D) shall be utilized to control cooling.
2. A three-position "ON-OFF-AUTO" SWITCH shall be provided for automatic and manual control of cooling equipment.
3. A toggle switch shall be provided in the control cabinet to provide manual switching between Stage 1 and Stage 2, regardless of APT programming.

2.15 Accessories

Accessory devices are to be insulated from ground for use with 125 DC source. Exception: Online dissolved gas & moisture monitor shall be powered by 120 volts AC.

All devices in the control cabinet shall be provided with a stainless steel nameplate indicating their function. This nameplate shall include all impedance ratings at rated voltage, no-load and load losses, current transformer ratings and locations, maximum operating pressures, tank vacuum filling pressure, oil level as measured below the manhole flange, and current ratings at all load tap changer or de-energized tap changer taps.

Alarm and trip circuits shall operate at 125 volts DC.

2.15.1 Transformer Monitoring

A transformer monitor shall be provided. Acceptable transformer monitoring systems manufacturer is APT Eclipse Monitor.

The transformer monitor shall be mounted on the swing panel in the main control cabinet and shall be visible through a viewing window on the door.

2.16 Monitored Signals

1. Discrete Signals - Refer to the attached transformer control schematic for alarms/annunciation required.
2. Analog Signals – The following analog signals shall be wired to the monitor.
   a. LV Winding Currents (X1, X2, and X3)
   b. Cooling Motor Current (Stage 1 and Stage 2)
3. RTD Temperature Signals and Sensors – The following RTD sensors shall be wired to the monitor.
   a. Top Oil
   b. Bottom Oil by Radiator Header

2.17 Cooling Control

1. Manual Control - The monitor will have the provisions to force individual banks of cooling to turn on under manual control. The transformer monitor will continue to monitor the cooling motor current against the expected current levels.
2. Automatic Control – The monitor shall have provisions to automatically control cooling.
   a. Separate set points for all stages of cooling will be provided for calculated winding temperature and measured top oil temperature.

b. Fan stage alternating will be programmable to allow for Stages 1 and 2 to be alternated on a daily basis, equalizing fan cycling.

c. A period of daily fan cycling will be programmable to exercise fan motors during periods of inactivity.

2.18 Sensors

1. Resistive Temperature Detectors (RTD's)

   a. RTD's shall be installed in dry wells

   b. RTD's shall have insulation rated to at least 200°C.

   c. RTD's of length greater than 10cm shall be 3-4 wires compensating for lead resistance.

   d. Maximum allowed error shall be +/- 1°C.

   e. Each RTD cable shall be at least 3 feet (91.4 cm) longer than necessary. Excess cable shall be coiled and shall be located within one foot (30.5 cm) of the RTD to facilitate RTD testing.

   f. The signal cable shield shall be grounded at the transformer monitor case.

2.19 AC Current Transducers/Signal Conditioners

1. Current transducers or signal conditioners shall be non-intrusive and shall not require disconnecting sensed current signal for removal or installation.

2. The signal cable shield shall be grounded at the transformer monitor case.

2.20 Construction

1. The manufacturer shall ensure the monitor is programmed prior to and functional during factory testing.

2. The manufacturer shall program the monitor with a current PGE settings file obtained from the monitor manufacturer. Settings shall be reviewed by PGE before programming.

   a. On-line Dissolved Gas and Moisture Monitor

   b. An on-line dissolved gas & moisture monitor shall be provided. Acceptable on-line dissolved gas & moisture monitor manufacturer and model shall be Qualitrol Serveron TM8-F or Owner approved equivalent.

   c. Monitors that require oil circulation shall be plumbed to main tank valves (described below) with flexible stainless steel tubing. Installation of tubing and monitor shall be performed in field by Qualitrol Serveron.

   d. Two stainless steel ball-type valves, full-port, shall be installed for the monitor on the transformer main tank. The first shall be located near the top of the tank, 12 inches below the lowest expected oil level, in an area with oil circulation, and shall be plumbed as the monitor's oil input from the main tank. The second shall be located at least 18 inches above the level of the drain valve and at least 48 inches away from the first valve, and it shall be plumbed as the oil return line from the monitor to the transformer. Valve size shall be 1/2" with female NPT outlet.

e. The monitor shall be provided with a dust cover over the monitor's manual oil sampling port.

f. Commissioning of monitor shall be performed in field by Qualitrol Serveron.

g. Magnetic Liquid-level Indicators

h. Acceptable liquid level gauge manufacturer shall be Messko.

3. One Main Tank Liquid-Level Indicator shall be located on the main tank wall and consist of the following:

   a. An alarm contact for low oil level.

   b. A trip contact that engages at an oil level at least 1.50 inches below the alarm level but at a level that will not cause damage to the transformer.

   c. No contacts are required for transformers with conservators. This gauge will be used for local oil level indication only.

   d. One Conservator Tank Liquid-Level Indicator shall be located on the conservator tank wall and consist of the following:

   e. An alarm contact for low oil level.

   f. A trip contact that engages at an oil level at least 1.50 inches below the alarm level but at a level that will not cause damage to the transformer.

4. The alarm and trip circuits shall include adjustable time delay relay set to delay annunciation or tripping after the contacts close.

5. Time delay relays shall be Signaline Model No. 360, 48 or 125 VAC/DC, 1-1023 seconds.

6. The trip circuit shall use a Qualitrol seal-in-relay 909-300-01 to provide a seal-in, trip and alarm for the trip circuit. For transformers with a conservator tank, the trip contacts from the main tank and conservator tank liquid level gauges shall be connected in series.

7. Alarms and/or trips shall not occur due to cold oil (minus 5°C for alarm and minus 15°C for trip). The trip shall not occur above the low-level mark on gauge.

2.20.1 Pressure Relief Devices

Acceptable pressure relief manufacturer shall be Messko. A minimum of two devices shall be located on the cover of the main tank, on opposite corners.

1. For inert gas pressure systems, a pressure relief of 8 PSI is required.
2. For conservator tank pressure systems, a pressure relief of 8 PSI is required.
3. One device shall be located on the Load-Tap-Changing compartment.
4. A pressure relief of 8 PSI is required.

2.20.2 Rate-of-Rise Fault Pressure Relay

Rate-of-Rise fault pressure relay and seal-in reset switch with alarm and tripping contacts.

2.20.3 Rapid Pressure Rise Relay

1. Qualitrol relay model 900-1, with Qualitrol seal-in-relay 909-300-01.
2. Qualitrol relay shall be installed in oil space.

2.20.4 Buchholz Relay

1. Cedaspe model EE3-ML + RG3.3, with Qualitrol seal-in-relay 909-300-01, and the following alarm and trip contacts.
   a. One Form-C trip contact for oil surge
   b. One Form-A trip contact for low oil level
   c. One Form-C alarm contact for gas accumulation

Trip and alarm contacts shall be connected to terminal blocks.

Sudden Pressure Relay shall operate on rate-of-rise pressure change to protect transformer against damage due to internal faults.

Relay shall be insensitive to pressure pulses caused by electrical disturbances such as magnetizing inrush currents, through faults, or mechanical shocks that may be caused by the normal operation of the transformer.

2.20.5 Bladder Integrity Relay

For a conservator tank system, a relay shall be installed to verify the integrity of the bladder system. Acceptable bladder integrity relay manufacturer shall be TREE Tech MBR.

2.20.6 Dial-Type Top-Oil Thermometer

Acceptable temperature gauge manufacturer shall be Messko.

Thermometer shall have three adjustable alarm contacts which close on temperature rise.

Mount remote readout less than 7 feet from transformer base.

2.20.7 Dial-Type Winding Thermometer

Dial-type winding thermometer and seal-in reset switch with alarm and tripping contacts.

Acceptable temperature gauge manufacturer shall be Messko.

For single phase, three winding transformers: Each winding shall have one thermometer.

For three phase, single tank transformers: Thermometer shall be furnished for B phase LV winding

Each thermometer shall have four adjustable contacts (alarm, trip, and two spare) which close on temperature rise.

The winding temperature indicator shall incorporate a current transformer responsive to its associated winding current, calibrating resistor, temperature detector element, and heater all mounted and connected to simulate the hot spot temperature of the winding.

The trip circuit shall use a Qualitrol seal-in-relay 909-300-01 to provide a seal-in, trip and alarm for the trip circuit.

Mount remote readout less than 7 feet from transformer base.

2.20.8 Transformer Nameplate

In addition to the requirements of IEEE C57.12.00, the transformer nameplate shall include the following:

1. Contractor transformer equipment number in upper left hand corner with extra-large lettering.
2. The current rating of the OLTC
3. The turns ratio of internal series or auto-transformers.
4. The minimum number of gallons of oil required to cover the core and coils.
5. The main tank & OLTC pressure & vacuum information (pressures shall be shown in PSI).
6. An adjacent nameplate shall show the various slings and lift positions required for proper lifting for the completely assembled transformer. It shall indicate whether the transformer may be lifted when filled with oil.
7. If tap voltages are not equally spaced, actual calculated tap voltages shall be indicated.
8. Transformer capacity ratings shall be stated in MVA, not kVA.
9. A simple plan view outline of the transformer showing bushings, control cabinet, OLTC tank and DETC handle locations.

10. Current transformers tap ratio tables.

2.20.9 Fiber Optic Connector Panel

Provide one Corning model CCH-CP12-25T fiber optic connector panel, installed in housing Corning model SPH-01P.

2.20.10 Ethernet Switch

Ethernet switch to convert Ethernet connections from transformer monitor and dissolved gas monitor to Ethernet fiber shall be provided. Acceptable manufacturer shall be Ruggedcom.

Switch shall be mounted inside control cabinet.

Minimum six RJ-45 ports shall be provided.

Minimum three ST multimode fiber connections shall be provided.

2.21 Alarms/Annunciator

All alarm/annunciation points shall be wired to the transformer monitoring device.

3 EXECUTION

3.1 Tank

3.1.1 Design

Tanks shall be of oil and gas-tight steel plate construction.

1. All seams shall be welded.
2. All butt welds shall be full penetration.
3. Weld slag and spatters shall be removed.
4. Field installation shall not require welding.
5. Corner welds on the tank are not allowed.

Tank and compartment walls shall be reinforced to permit drawing full vacuum on each compartment, with oil in adjacent tanks or compartments.

Tank and all other oil-filled compartments shall be designed to withstand, without permanent deformation, an internal pressure of 10 PSI.

Transformer designs using an oil expansion conservator tank shall be designed to channel all generated gases to a Gas Accumulation Relay. Gas-channeling piping shall not cause a tripping hazard for personnel walking on the transformer cover.

The CENTER OF GRAVITY shall be visibly and permanently marked on two adjacent sides of the tank and shall be appropriately identified as follows:

1. “CENTER OF GRAVITY - COMPLETE” for the completely assembled transformer filled with oil.
2. “CENTER OF GRAVITY - SHIP” for the transformer filled with oil, but without the radiators, bushings, and lightning arresters.

Lifting lugs shall be provided for lifting the completely assembled transformer.

Jacking bosses shall be provided at all four corners of base for jacking the completely assembled transformer with oil.

1. Boss pads shall be located a minimum of 13 inches above the transformer foundation
2. The area above the pads shall be clear of obstructions.

Transformer tank shall withstand skidding or rolling the transformer with oil, bushings, and radiators in a direction parallel to either center line of the tank.

Provision for anchors or tie downs to the foundation shall be provided.

Provide weatherproof penetration box for current transformer leads on upper tank wall.

3.1.2 Cover

Cover shall be welded to tank.

Opening(s) shall be provided to facilitate installation and removal of bushing current-transformers without removal of the tank cover.

The transformer cover shall have external lifting eyes, which shall be welded on.

All manholes, hand holes, and inspection openings shall have a gasketed, bolted cover with external lifting provisions.

All openings in the tank cover employing gaskets shall be raised above the cover surface to prevent the accumulation of water around the gasket joints.

Covers shall not trap any gas generated in transformer.

Lifting eyes shall be welded inside the tank cover at all 4 corners and approximately 1 foot from each wall to be used for emergency man lifting.

Install Pelsue FB-SW1 (same as former UNI-Hoist NUH-4000-2) weld on adapter plates for confined space entry/retrieval system.

1. One retrieval system adapter plate shall be located near each man-hole.
2. One retrieval system adapter plate shall be located on the edge of the transformer, near the clean side of the transformer as recommended by retrieval system manufacturer.
3. Quantity and spacing between plates to be determined based on transformer capacity and manufacturer requirements.

Manufacturer shall apply non-skid paint on the entire transformer tank cover.

3.2 Sound

The transformer shall be designed to comply with a decibel rating of -10 dB relative to NEMA TR1

3.3 Safety Features

3.3.1 Clearance

There shall be sufficient clearance from ground to live parts, in accordance with the NESC, to permit access to parts, which require adjustments or examination by operators while the transformer is energized.

3.3.2 Caution Labels

For nitrogen gas pressure systems a caution label shall be provided on the top of each manhole cover. The nameplate shall read as follows:

"DANGER, Pressurized with Nitrogen Gas –

1. Reduce gas pressure to zero before opening.
2. Ventilate with dry air and follow confined entry procedure to enter the transformer."

For conservator-type transformers a caution label shall be provided on the top of each manhole cover. The nameplate shall read as follows:

"WARNING, Oil must be removed from the conservator tank before opening."

For tank ribs that are pressurized a caution label shall be provided on each pressurized rib. The label shall read as follows

"DANGER, Rib is pressurized, do not drill, puncture or weld."

For manholes mounted on the tank wall a caution label shall be provided on each manhole cover. The label shall read as follows

"WARNING, Oil must be removed from the main tank before opening."

For transformers with a de-energized tap changer a caution label shall be provided next to the de-energized tap changer handle. The label shall read as follows:

"DANGER: Do not operate the de-energized tap changer with the transformer energized."

3.4 Seismic

The transformer and all of its components shall be qualified in accordance with IEEE Standard 693 and IBC code. Transformer shall meet the requirements of the High Seismic Qualification Level.

At a minimum the follow upgrades shall be included to ensure qualification:

1. Additional radiator supports
2. Additional conservator supports
3. Additional control cabinet supports
4. Increased bracing of the active part

A note shall be added to the nameplate that indicates that the transformer was designed to meet the IEEE 693 High Seismic Qualification Level.

A finite element analysis shall be done and report, verified by a registered professional engineer, shall be submitted to verify the High Seismic Qualification Level.

4 Factory Tests

4.1 General

The manufacturer shall notify Contractor at least 30 days prior to commencement of testing so that a Contractor/Owner representative may witness the tests. The manufacturer shall notify Contractor immediately of any delays.

The tests specified in IEEE Standard C57.12.00 and manufacturer's quality control tests, shall be performed, except as stated in this specification.

Tests, which have been run on other transformers of essentially duplicate designs, are not acceptable in lieu of the tests specified, except as stated in this specification.

All tests shall be performed in accordance with IEEE Standard C57.12.90, unless otherwise specified by the Contractor/Owner. The manufacturer shall notify Contractor immediately of any test results not in compliance prior to any modifications and retesting.

Contractor/Owner will accept the transformer only if it has passed all tests to Contractor/Owner's satisfaction.

All dielectric tests shall be performed after the heat run.

All tests shall be performed on all units (including duplicates).

4.2 Specific Tests

4.2.1 Bushing Tests

Immediately after receiving the bushings into the factory, the bushings shall be thoroughly inspected, cleaned, and shall receive power factor and capacitance tests.

4.2.2 Winding Resistance Tests

Resistance measurements and impedance voltage tests of all windings on rated voltage connection and at tap extremes.

1. The same method shall be used to determine both cold-resistance and hot-resistance values (same winding resistance meter, same test leads, same connections, same current, etc.).
2. The same method shall be used to determine both the temperature associated with the cold-resistance test and the temperature associated with the hot thermal tests (same measuring device, same RTDs/probes, same calculation to determine mean oil temperature, etc.).
3. Cold resistance measurements shall be made in the following tap positions:
4. Windings with a DETC: neutral and extreme tap positions
5. Resistances for windings in a delta configuration shall be measured phase-to-phase.
6. Resistances for windings in a wye configuration shall be measured phase-to-neutral.

4.2.3 Ratio Tests

Ratio tests on rated voltage connection and on all tap connections.

4.2.4 Polarity Tests

Polarity and phase-relation tests on rated voltage connection.

4.2.5 No-Load Losses

The no-load losses test shall be repeated after dielectric tests (repeated with 100% voltage, with tap changers in the nominal positions). The test shall be sustained for at least 10 minutes to help ensure the core is well demagnetized for subsequent tests.

Values from the repeat test shall be used to evaluate actual losses compared to the guarantee losses stated in the Proposal.

No-load losses and excitation current shall be reported at 60 Hz, and 90%, 100%, 105%, 110% rated voltages (before and after dielectric tests).

4.2.6 Excitation Tests

Excitation current test at 100 percent, 105 percent, and 110 percent of rated voltage on the rated voltage tap.

1. Excitation tests shall be performed before the impulse tests.
2. The 100 percent test shall be repeated after the impulse test.

4.2.7 Load Loss and Impedance Tests

Impedance and load loss at rated current and rated frequency on the rated self-cooled ONAN connection and on the tap extremes.

4.2.8 Zero Sequence Test

Measured zero sequence impedances (primary-to-secondary, secondary-to-tertiary, and primary-to-tertiary as applicable) shall be reported in the certified test report, at the ONAN rating and the following voltage taps:

1. Units with only a DETC: neutral and extreme tap positions
2. Units with only a load tap changer: neutral and extreme tap positions

4.2.9 Temperature Rise Tests

Temperature rise tests shall be per IEEE Standard C57.12.90.

1. ONAN temperature rise test.
    a. Winding resistance measurement taken on one phase.
2. ONAF temperature rise test.
    a. Winding resistance measurements taken on all three phases.
    b. The tank wall surfaces shall be checked for hot spots with thermal imaging camera when the top oil temperature has stabilized.
    c. Thermal images shall be provided to Contractor/Owner electronically with the test report.
    d. Overload Test shall immediately follow the ONAF temperature rise test.
    e. With all cooling equipment in operation, and after the top oil rise is re-established and with the total losses of the ONAF rating being applied, the loading shall be increased to 125% of maximum ONAF rating and held until stabilized.
    f. Winding resistance measurement shall be taken on the hottest phase recorded from the ONAF temperature rise test.
    g. The top oil rise shall be limited to 60°C rise over 50°C ambient (110°C absolute).
    h. The hot spot rise shall be limited to 80°C rise over 50°C ambient (130°C absolute).
3. Any test shall be terminated if the winding, lead, bushing, and metal hot-spot temperature exceeds 80°C rise over 50°C ambient.
4. Top & bottom oil temperature, simulated hottest-spot winding temperature, and fiber optic temperatures shall be operational and recorded at intervals of

30 minutes or less. Any test shall be terminated if any fiber optic hot spot winding temperature exceeds 140°C.

5. Transformer monitor and fiber monitor (defined in Section 2.15.1) shall be configured to record all temperatures from RTD and fiber optic temperature probes at 1 minute intervals prior to heat run tests. Transformer monitors shall be energized and shall log all temperature inputs for the duration of all heat run tests.
6. The online DGA monitor specified in 2.15 (E) shall be fully plumbed, commissioned, and operating during the heat run tests.

4.2.10 Dissolved Gas Analysis (DGA)

DGA samples shall be taken from the main tank as follows and shall be analyzed using test method ASTM D3612:

1. Prior to any testing.
2. After ONAN temperature rise test.
3. After ONAF temperature rise test shutdowns.
4. After overload test or before dielectric tests if not performed on the same day.
5. After dielectric tests.
6. Prior to shipping if the transformer is being shipped filled with oil.

Cumulative dissolved gases in oil resulting from any test shall not exceed:

Gas	After ONAN or ONAF Test	After Dielectric Tests
Acetylene	0 ppm	0 ppm
Hydrogen	10 ppm	15 ppm
Carbon Monoxide	20 ppm	40 ppm
Carbon Dioxide	200 ppm	200 ppm
Methane	2 ppm	4 ppm
Ethylene	1 ppm	2 ppm
Ethane	2 ppm	4 ppm

4.2.11 Impulse Test

Switching and lightning impulse tests shall be performed in accordance with the requirements of IEEE C57.12.90 and IEEE C57.12.00. Measurement of test voltages shall be performed based on IEEE Std. 4.

The dielectrics tests shall be performed in the following sequence:

1. Lightning impulse tests (on all terminals)

2. Switching impulse tests
3. Applied potential test
4. Induced potential test

4.2.12 Applied Potential Test

Applied potential tests shall be performed in accordance with the requirements of IEEE C57.12.90 and IEEE C57.12.00 at low frequency (below 500 Hz) and duration of 1 minute. Measurement of test voltages shall be performed based on IEEE Std. 4.

4.2.13 Induced Potential Test

RIV measurements (in microvolts) and partial discharge measurements (in picocoulombs) shall be performed at the end of all dielectric tests Values shall be recorded for each phase in both microvolts and picocoulombs.

1. The test shall be recorded on at least 6 channels (3 RIV and 3 PD).
2. Limiting criteria for the test is as follows:
   a. Maximum RIV < 100 microvolts
   b. Maximum PD < 300 picocoulombs
   c. Increase of RIV during 60 minutes does not exceed 30 microvolts
   d. Increase of PD during 60 minutes does not exceed 50 picocoulombs
   e. No steadily rising trend in RIV or PD during the last 20 minutes
   f. The RIV and PD of any one phase shall not be higher than 200% of another phase (desire somewhat symmetrical values across phases)
3. If the limiting criteria is near the failure limit and/or is steadily increasing near the conclusion of the test, the test length shall be extended indefinitely until a confident judgment can be made as to whether the transformer has passed or failed.

4.2.14 Audible Sound Level Tests

Sound level tests shall be performed per IEEE C57.12.00 and IEEE C57.12.90.

1. Performed at the tap position that produces the highest audible sound level.
2. The test shall be performed a second time with both the first and second stages of auxiliary cooling energized.
3. The test report shall include all test data taken with corresponding locations of microphones at all tap settings in accordance with the referenced standards.

4.2.15 Insulation Power Factor and Excitation Tests

Power factor and excitation tests of the transformer, with bushings and oil installed, shall be performed at 10 KV before and after dielectric and load tests are complete.

1. The individual tested power factors of the winding-to ground insulation and of the inter-winding insulation (CH, CL, and CHL by Doble Method II) shall not exceed 0.50 percent at 20°C top oil temperature.
2. Power factors for bushings C1 and C2 shall be tested.

4.2.16 Current Transformer Tests

The insulation resistance and polarity of all current transformers shall be tested.

4.2.17 Sweep Frequency Response Analysis (SFRA)

Provide Sweep Frequency Response Analysis test (at nominal test positions) on all windings using Doble SFRA test equipment. To ensure the core is free of any residual magnetization due to impulse tests, the SFRA test shall follow the repeated no-load test (after impulse test). The test shall be performed with the DETC in the maximum voltage position (all winding in the circuit).

4.2.18 Furanic Compound Analysis

Analysis shall be performed after all tests, prior to removing test oil from transformer, on the main tank, DGA-syringe sample using test method ASTM D5837.

4.2.19 Oil Quality Tests

If the transformer is to be shipped with oil, oil quality tests shall be performed on the oil shipped in the transformer prior to shipping. The sample for the oil quality tests shall be taken from the main tank. The oil quality tests shall include the following:

1. Interfacial Tension @ 25°C, min, dynes/cm – ASTM D971
2. Dielectric Breakdown, min, KV – ASTM D1816
3. Power factor, max 25°C, % – ASTM D924
4. Power factor, max 100°C % – ASTM D924
5. Water, max, ppm – ASTM D1533
6. PCB content, ppm – EPA 8082
7. Acid Number, mg KOH/g – ASTM D974
8. Any oil that will be provided with the transformer shall be tested for corrosive sulfur in accordance with ASTM D1275 Modified (b) and shall be classified as

non-corrosive. A copy of this report shall be provided upon delivery of the transformer.

9. Oxidation Inhibitor content, % by weight – ASTM D2668
10. Relative density – ASTM D1298

4.3 Test Report

All test data shall be recorded in the Test Report. The Test Report shall be accompanied by copies of the raw hand-written data sheets used to record test results, including, but not limited to:

1. Tests completed for setup and calibration.
2. Tests repeated due to incomplete test records.
3. Test failures.
4. Test records incorporated into the final report.

The manufacturer shall e-mail a copy of the certified test report to Contractor/Owner for approval prior to shipment. Final copies of the test report shall be included in each instruction book and provided in electric form to Contractor/Owner. The report shall include a short summary noting any abnormal results and stating if the unit has passed or failed. The following test data shall be provided for review.

1. Winding Resistance (All tests)
2. No-load losses, Load losses & Impedance tests (All tests)
3. Excitation Current (All tests, 100%, 105%, 110% and 100% after dielectric tests)
4. TTR Results (All taps with deviation from equally spaced taps)
5. Impulse tests (including waveform comparisons, i.e. reduced wave vs. full wave, chopped wave 1 vs. chopped wave 2, etc.)
6. Induced voltage test results (all micro-volt and pico-coulomb readings)
7. Sound Level (All data points)
8. 10kV Power Factor and Excitation data (in test report and separately in Doble .XML file)
9. Doble SFRA test results (in test report and separately in Doble .SFRA files)
10. Oil sample results (All tests, including DGA, oil quality, furanic compounds, and corrosive sulfur)
11. Bushing Power Factor and Capacitance Tests (in test report and to be included in Doble .XML file specified in item 8 above)

12. Provide continuous log, in the test report and EXCEL file, of all temperatures (fiber, bottom and top oil, top and bottom header, ambient, and customer temperature gauges) and transformer loading, with date and time stamps for the temperature rise and overload tests. Provide shutdown plots of resistance.

The Test Report shall show the stray loss ratio, i.e.:

1. SFL = Stray losses / Full Load Losses
2. Full Load Losses = Total load losses - I^2R Losses X 100 % / Total load losses The Test Report shall show no-load losses at 90 percent, 100 percent, 105 percent, and 110 percent of rated voltage.

The Test Report shall show the manufacturer's quality control sound level test, including noise data by location.

The Test Report shall include ratio test results with deviation from equally spaced taps.

The Test Report shall show induced voltage test results in time vs. measurement table format. (Both RIV and picoCoulombs.)

The Test Report shall indicate PCB level of oil used for tests.

The Test Report shall include winding temperature indicator calibration value and the winding hot spot temperature rise above top oil for every heat run test shutdown.

Test Report shall include all oil test reports, including the manufacturer's ASTM D3487. The D3487 test should be from one of the tankers that deliver oil to the transformer manufacturer during the time our transformer is being filled or tested.

4.4 Short Circuit Requirements

The manufacturer shall furnish information and type test data to document that a transformer of similar design that is being furnished is capable of withstanding, without damage, the mechanical stresses caused by short circuits imposed at the bushing terminals of the secondary windings under the conditions specified in the American National Standard for Distribution and Power Transformer Short-Circuit Test Code (C57.12.90, Part II).

The transformer shall be capable of withstanding maximum expected short circuit currents which flow to any winding due to a fault at any terminal at 1.05 per-unit voltage for the maximum duration as defined by the interconnection agreement or PGE specifications, whichever is longer.

5 Assembly and Oil Filling:

The Contractor shall furnish all labor, supervision, material, and equipment required to attach all auxiliary equipment that is shipped separate from the transformer tank(s) and completely fill the transformer(s) with oil.

Prior to oil filling, the following tests shall be performed on the oil:

1. Moisture content
2. Dielectric strength
3. Power factor
4. Interfacial tension
5. Neutralization number
6. After filling with oil, check transformer(s) for oil and pressure leaks.

Facilities for lifting the coil and core assembly shall be provided by the manufacturer and shall comply with ANSI C57.12.10.

6 Field Inspections and Tests

The transformer supplier shall perform and record the following field inspections and tests upon delivery of the transformer(s) to the site:

1. Check impact recorder
2. Check blocking
3. Check transformer tank and fittings for the following:
    a. External damage
    b. Paint finish
    c. Attached fittings
    d. Oil leakage, if shipped oil-filled
    e. Positive pressure or vacuum in tank
4. Inspect bushings
5. Perform the following internal inspections:
    a. Check for moisture
    b. Check coil supports
    c. Disconnect core ground and measure insulation to ground to verify no unintentional grounds
    d. Check for any visible insulation damage
    e. Check for any loose parts
6. Check that all parts have been delivered and report and expedite shipment of any missing or damaged parts
7. Provide and record the following field tests:

   a. Insulation resistance
   b. Each winding-to-ground and to other windings
   c. Core-to-ground
   d. Winding ratio tests on all tap positions
   e. CT ratio and polarity tests
   f. Dissolved gas analysis sampled at least one day after energized

8. Compare results with factory test report and inform Contractor/Owner of any discrepancies.
9. Check and report on all accessories for proper operation, including the following:
   a. Cooling fans
   b. Oil pumps, if applicable
   c. Cooling controls
   d. Pressure relief device
   e. Sudden pressure relay
   f. Magnetic liquid level indicator
   g. Winding temperature indicators
   h. Liquid temperature indicator
   i. Pressure-vacuum indicator
   j. Tap changer
   k. Winding temperature detectors
10. Provide all additional field inspections, adjustments, and tests recommended by the transformer manufacturer.

APPENDIX M1

ATTACHMENT 05

EXHIBIT 03

SUBSTATION DESIGN AND CONSTRUCTION SPECIFICATIONS

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

REQUEST FOR PROPOSAL

NO.	DATE	REVISION	BY	CHK'D	APPROVALS	
0	26Oct21	Issued for Implementation	1898 & Co.		JAL	Jared Lathrop
1	14Apr23	Update from 2021 Version	1898 & Co.	PGE	CPA	Craig Armstrong

M1-05-03-Substation Design and Construction Specifications

SPECIFICATION INDEX

SECTION 1 - GENERAL

SECTION 2 - SITE WORK

SECTION 3 - CONCRETE

SECTION 4 - FENCING

SECTION 5 - METALS

SECTION 6 - ELECTRICAL

1 SECTION 1 - GENERAL

1. SECTION 1000 SUMMARY OF WORK

1.1.1 GENERAL

1.1.2 DESCRIPTION OF PROJECT

The XXXX Project consists of constructing XXXX

1.1.3 WORK PERFORMED BY CONTRACTOR

The Contractor's scope will include all below grade and above work required to complete construction including but not limited to the following tasks.

Incidental work and materials required to provide a complete and functional substation shall be the responsibility of the Contractor.

All work shall be in accordance with this specification, applicable contract exhibits, Owner-approved design specifications, and the drawings.

1.1.4 WORK PERFORMED BY PGE

1.1.5 PGE PROVIDED MATERIALS

MATERIAL	PLANNED DELIVERY

The Contractor will be responsible for receiving and storing the equipment if the substation location has not been deemed to be ready by the Owner. If the Contractor is unable to receive the materials when they are delivered, the Contractor is responsible for any additional storage or shipping.

1.1.6 CONTRACTOR PROVIDED MATERIALS

Contractor is responsible for providing material quantities required for construction, except for those identified in section 1.4. Quantities will not be adjusted for actual quantities installed.

1.1.7 WORK SEQUENCE

Contractor shall propose a detailed work schedule for PGE's approval.

1.1.8 ATTACHMENTS

- Engineering and Construction Standards
  - MP-6C-ALL-002 – Generic Baseline for New Gas Breakers
  - MP-6C-VAC-001 – Generic Baseline for Vacuum Breakers
  - MP-6G-ALL-004 – Circuit Breaker Checkout Procedure
  - MP-11G-ALL-004 – Transformer Testing
  - MP-12G-ALL-003 REV 1 – Doble 3100 Timer Operating Instructions
  - MP-15G-INST-TESTS-REV 3 – Testing Instrument Transformers
  - S-116-25 – Potential Fuse Box

- S-130-50 – Animal Deterrents
- S-131-40 – Bolted Pad Connections
- S-140-06 – Metal Building Grounding
- S-140-09 – Capacitor Bank Grounding
- S-140-12 – Outdoor Enclosure and Cabinet Grounding
- S-140-15 – Fence and Gate Grounding
- S-140-16 – Barb Wire Grounding
- S-140-21 – Ground Grid and Structures
- S-140-24 – Instrument Transformer Grounding
- S-140-27 – Switch Handle and Operator Grounding
- S-140-31 – Power Transformer Grounding
- S-144-10 – Control Wiring
- S-144-10 Addendum – Control Wiring
- S-140-30 – Underground 15kV Power Cable
- STND-1300 Substation Raceway Systems
- STND-1400 Substation Lighting

- Evaluation Questions
- West Union Geotech report
- Testing Checklist for Contractor (TCC)
- Switchgear 1&2 Vendor Drawings
- C&P IFC 4-3-15
- Physical IFC 4-2-15
- Civil IFC 4-9-2015

2. SECTION 1020 QUALITY CONTROL

1.1.9 GENERAL

A. The Contractor shall ensure that subcontractors are approved by the Owner and satisfy the Owner required qualification/approval process prior to work being performed by the proposed Subcontractor.

1.1.10 QUALITY ASSURANCE

B. Contractor shall monitor quality control over suppliers, manufacturers, products, services, site conditions and workmanship to produce work which meets quality requirements as set forth in applicable contract specifications. Locations of existing structures, utilities and other site conditions indicated on the drawings are approximate, and shall be the Contractor's responsibility to verify the true and correct locations so as to avoid interferences, damages or disturbances. Deviations from information indicated on the drawings shall be brought to the immediate attention of the Owner. New construction shall accommodate existing conditions.

Prior to any excavation the Contractor shall call for primary power cable locates by a PGE Special Tester. To schedule a PGE Special Tester call **PGE's Power Quality Hotline at 503-572-0395.**

C. Contractor shall comply with manufacturer's instructions including performing each step in sequence. Should instructions conflict with contract documents, request clarification from Owner before proceeding. All fabrication and installation shall comply with the drawings and specifications. Should information provided on the drawings conflict with that in the specifications, request clarification from the Owner before proceeding.

D. Contractor shall comply with specified standards as minimum quality for the work. The exception is where standards, by code or by requirements of construction permits, indicate higher standards or workmanship that is more precise is required.

1.1.11 TOLERANCES

E. Contractor shall comply with manufacturer's tolerances. Should manufacturer's tolerances conflict with contract documents, request clarification from Owner on which tolerances should be used before proceeding.

1.1.12 INSPECTING, TESTING AND LABORATORY SERVICES

F. Contractor will employ the services of an independent firm to perform testing and inspection services. The independent firm will perform inspections, tests and other services specified in individual specification sections or as required by the Owner.

G. Reports will be submitted by the independent firm to the Owner indicating observations and results of tests and indicating compliance or non-compliance with the specifications.

H. Contractor shall cooperate with the independent firm and furnish samples of material, design mix, and provide equipment, tools, storage, safe access and assistance by incidental labor as requested.

I. Testing or inspecting does not relieve Contractor of responsibility to perform work in compliance with contract requirements.

J. The same independent firm, on instruction by the Owner, shall perform retesting required because of non-conformance to specified requirements by the Owner. Payment for retesting will be charged to the Contractor by deducting inspecting or testing charges from the Contract price.

1.1.13 MANUFACTURER'S FIELD SERVICES AND REPORTS

K. If the Owner, scope of work, or material specification requires the manufacturer to provide qualified staff personnel to observe site conditions, conditions of surfaces and installation, quality of workmanship, or startup of equipment, the Contractor shall arrange and coordinate such activities.

L. The Contractor will supply the Owner with certified originals or copies of all equipment or material test completed by manufacturers and/or specified by Owner specifications and/or scope of work.

1.1.14 CONTRACTOR HOLD POINTS

Contact PGE at the following times during construction for a PGE site review of work to the drawings and specifications:

- After compaction and backfill.
- After completion of grading.
- After completion of drilling holes for pier foundations and prior to placement of rebar cage.
- For all other foundations, after rebar is installed and before pouring concrete.
- Special inspections for rebar and concrete placement.
- Prior to installing any major equipment on concrete slab foundations to check for flatness.
- Before covering conduits & grounding connections.
- After completion of all sub-grade conduit & grounding installations and before placement of geo-textile fabric and final aggregate surfacing.
- After completion of all steel structure erection and disconnect switch and switch operator placement. Verify disconnect switch operation before punching set screws.
- After completion of the placement of all 115kV & 15kV equipment and bus work and bus jumpers to equipment
- After bolted electrical connections and enclosure assembles are made. PGE to verify torqueing requirements.
- During the pulling of control cables to and from major equipment into control enclosures.
- During control cable terminations.
- After major equipment testing.

3. SECTION 1030 TEMPORARY CONSTRUCTION FACILITIES

1.1.15 General

1.1.16 Temporary Utilities

Owner will provide the following utilities to the Contractor at no cost. Contractor is responsible for connection, maintenance and removal of all temporary utilities. Owner does not guarantee continuity of service. Contractor shall minimize disruption to Owner during connection and removal activities.

All utilities not listed that are required shall be provided by Contractor

- Owner will only provide electrical utility for Contractor. Contractor shall coordinate and provide a month notice to Owner for electrical utility requirements.
- Contractor shall provide a three phase, 400VAC, 50kW generator for GIS gas cart and supply all fuel necessary to operate the generator.

1.1.17 Temporary Controls

A. Barriers: Contractor shall provide barriers or barricades as required to prevent unauthorized entry to construction areas and protect existing facilities and adjacent properties from damage from construction operations.
B. Fence:

- Contractor shall provide temporary fencing as shown on the drawings or as required to maintain security.
- Any temporary fence installed that functions as the substation perimeter fence shall be installed in accordance with PGE's fence and fence grounding standards. With approval from PGE the temporary perimeter fence posts may be directly embedded into the soil without concrete.

C. Traffic Control: Contractor shall provide traffic control measures including signing, flagging and other traffic control measures as required to maintain safe access into and through the construction area and any other traffic control measures that may be required by local agencies.

1.1.18 Temporary Facilities

M. Field Office: Contractor shall provide a weather tight construction office complete with lighting, heating and cooling equipment. Office shall include space for Owner's Inspector or other personnel.

N. Temporary restrooms shall be available and shall be outfitted for conditions (i.e., space heated in the winter, if necessary).

4. SECTION 1040 CONTRACT CLOSEOUT

1.1.19 General

1.1.20 Summary

A. This Section includes administrative and procedural requirements for contract closeout including, but not limited to, the following:

1. Inspection procedures
2. Project record document submittal
3. Submittal of warranties
4. Final cleaning
5. Refer to M1-02-01 (General Civil Specs) for detailed reclamation requirements

1.1.21 Substantial Completion

A. Preliminary Procedures: Before requesting inspection for certification of Substantial Completion, complete the following. List exceptions in the request.

1. In the Application for Payment that coincides with, or first follows, the date Substantial Completion is claimed, show 100 percent completion for the portion of the Work claimed as substantially complete.
    - a) Include supporting documentation for completion as indicated in these Contract Documents and a statement showing an accounting of changes to the Contract Sum.
    - b) If 100 percent completion cannot be shown, include a list of incomplete items, the value of incomplete construction, and reasons the work is not complete.
2. Advise the Owner of pending insurance changeover requirements.

3. Submit specific warranties, workmanship bonds, maintenance agreements, final certifications, and similar documents.
4. Obtain and submit releases enabling the Owner unrestricted use of the work and access to services and utilities. Include occupancy permits, operating certificates, and similar releases.
5. Submit final record information.
6. Make final changeover of permanent locks and transmit keys to the Owner. Advise the Owner's personnel of changeover in security provisions.
7. Discontinue and remove temporary facilities, construction tools, and similar elements from the site.
8. Complete final cleanup requirements.
9. Touch up and otherwise repair and restore marred and exposed finishes.
10. The Contractor will submit their internal QA process which will indicate any outstanding construction issues.

B. Inspection Procedures: On receipt of a request for inspection, the Owner will either proceed with inspection or advise the Contractor of unfilled requirements. The Owner will prepare the Certificate of Substantial Completion following inspection or advise the Contractor of construction work that must be completed or corrected before the certificate will be issued.

1. The Owner will repeat inspection when requested and when assured that the work is substantially complete.
2. Results of the completed inspection will form the basis of requirements for final acceptance.

1.4 Final Acceptance

A. Preliminary Procedures: Before requesting final inspection for certification of final acceptance and final payment, complete the following. Create a list of exceptions in the request.

1. Submit the final payment request with releases and supporting documentation not previously submitted and accepted. Include insurance certificates for products and completed operations where required.
2. Submit an updated final statement, accounting for final additional changes to the Contract Sum.
3. Submit a certified copy of the Owner’s final inspection list of items to be completed or corrected, endorsed and dated by the Owner. The certified copy of the list shall state that each item has been completed or otherwise resolved for acceptance and shall be endorsed and dated by the Owner.
4. Submit consent of surety to final payment.
5. Submit evidence of final, continuing insurance coverage complying with insurance requirements.

B. Re-inspection Procedure: The Owner will re-inspect the Work upon receipt of notice that the work, including inspection list items from earlier inspections, has been completed, except for items whose completion is delayed under circumstances acceptable to the Owner.

1. Upon completion of re-inspection, the Owner will prepare a certificate of final acceptance. If the work is incomplete, the Owner will advise the Contractor of work that is incomplete or of obligations that have not been fulfilled but are required for final acceptance.
2. If necessary, re-inspection will be repeated.

1.5 Record Document Submittals

A. General: Do not use record documents for construction purposes. Protect record documents from deterioration and loss in a secure, fire- resistant location. Provide access to record documents for the Owner's reference during normal working hours.

B. Record Drawings: Maintain a clean, undamaged set of black line prints of Contract Drawings and Shop Drawings. Mark the set to show the actual installation where the installation varies substantially from the Work as originally shown. Mark which drawing is most capable of showing conditions fully and accurately. Where Shop Drawings are used, record a cross-reference at the corresponding location on the Contract Drawings. Give particular attention to concealed elements that would be difficult to measure and record later.
   1. Mark three record sets with red erasable pencil. Use other colors to distinguish between variations in separate categories of the work.
   2. Mark new information that is important to the Owner but was not shown on the Contract or Shop Drawings.
   3. Note related change-order numbers where applicable.
   4. Organize record drawing sheets into manageable sets. Bind sets with durable-paper cover sheets; print suitable titles, dates, and other identification on the cover of each set.

C. Record Specifications: Maintain one complete copy of the Project Specifications, including addenda. Include with the Project Specifications one copy of other written construction documents, such as Change Orders and modifications issued in printed form during construction.
   1. Mark these documents to show substantial variations in actual work performed in comparison with the text of the Specifications and modifications.
   2. Give particular attention to substitutions and selection of options and information on concealed construction that cannot otherwise be readily discerned later by direct observation.
   3. Note related record drawing information and Product Data.
   4. Upon completion of the work, submit record Specifications to the Owner for the Owner's records.

D. Record Product Data: Maintain one copy of each Product Data submittal. Note related Change Orders and markup of record drawings and Specifications.
   1. Mark these documents to show significant variations in actual work performed in comparison with information submitted. Include variations in products delivered to the site and from the manufacturer's installation instructions and recommendations.
   2. Give particular attention to concealed products and portions of the work that cannot otherwise be readily discerned later by direct

observation.

3. Upon completion of markups, submit a complete set of record Product Data to the Owner for the Owner's records.

E. Miscellaneous Record Submittals: Refer to other Specification Sections for requirements of miscellaneous record keeping and submittals concerning actual performance of the work. Immediately prior to the date or dates of Substantial Completion, complete miscellaneous records and place in good order. Identify miscellaneous records properly and bind or file, ready for continued use and reference. Submit to the Owner for the Owner's records.

5. SECTION 1050 CONTRACT ADMINISTRATION PROCESS

1.1.22 GENERAL

1.1.23 PLANS AND SPECIFICATIONS

The Contract Documents govern the Work to be done, set forth the relative responsibilities of the Owner and Contractor, and establishes the method by which changes in the Contract are made.

Some details of the Work may be found in only one location in the Contract Documents. Therefore, the Contractor must review all portions of the Contract Documents in order to know the full scope of Work. Including, but not limited to PGE Standard Construction and Design Documents.

All civil works for the Project Substation shall comply with the applicable specifications in M1-02-01-General_Civil_Specs.

1.1.24 PRECEDENCE OF CONTRACT DOCUMENTS/CONFLICTS

Obvious conflicts in the Contract Documents, or obvious omissions, are ones that should have been discovered before submission of a Bid to the Owner by a reasonable person in the Contractor’s position if all the Documents had been reviewed. In such a situation, the Contractor has a duty to inquire of the Owner before submitting its Bid about the correct interpretation of the Contract. This permits the Owner to clarify by Addendum what is intended by the Contract. That is particularly true for errors in figures, drawings or Specifications.

If the Contractor fails to bring an obvious conflict or error to the Owner’s attention before it submits a Bid, it has waived its right to additional compensation when the Owner resolves it.

Anything shown on the Plans and not mentioned in the Specifications or Standards, or mentioned in the Specifications and Standards and not shown on the Plans, shall be of like effect as if shown or mentioned in both. This does not constitute a conflict, discrepancy or error between the two.

In cases of apparent discrepancies or conflicts between the Plans, the Specifications and the Standards, the Contractor shall first determine if the matter can be resolved pursuant to the rule stated above. If not, the apparent conflict shall be resolved by designating the portion of the Contract Documents that takes precedence over the others. Therefore, when preparing its Bid, or when beginning any portion of the Work, the Contractor shall use the following order of precedence to resolve any apparent conflict:

- Permits from Outside Agencies required by law
- Change Orders
- Addenda
- Technical Specifications
- Plans
- Information furnished by written notes and/or schedules on drawings
- Large Scale Drawings over small scale drawings
- Information provided by lines on drawings
- General Conditions of the Contract

Contractor shall bring any real or perceived discrepancy concerning dimensions, quantities or location between the Drawings, details, Specifications or Standards to the attention of the Owner's Representative before beginning that portion of the Work.

In the event of any inconsistency in the Drawings, Specifications and Standards unless otherwise ordered in writing by the Owner's Representative, the Contractor shall provide the better quality of, or the greater quantity of Work or materials. This provision shall apply only to inconsistencies in express requirements of the Drawings, Specifications and Standards and not the interpretations by the Owner or Architect.

1.1.25 SHOP DRAWINGS AND SUBMITTALS

For purposes of this subsection the following definitions apply:

- All drawings and submittals shall comply with the applicable specifications in M1-01-02-Eng_Docs_Dwgs_and_other_Deliverables and results of the studies as specified in M1-04-01-General_Electrical_Study_Requirements.
- "Shop Drawings" are drawings, diagrams, schedules and other data specifically prepared for the Work by the Contractor, a Subcontractor at any tier, manufacturer, supplier or distributor to illustrate some portion of the Work.
- "Product Data" are illustrations, standard schedules, performance charts, instructions, brochures, diagrams and other information furnished by the Contractor to illustrate materials or equipment for some portion of the Work.
- "Samples" are physical examples that illustrate materials, equipment or workmanship and establish standards by which the Work will be judged.
- "Submittals" are documents required by the Contract to be submitted to the Owner for review. However, they are not part of the terms and conditions of the Contract. They may include shop drawings, product data, samples, or a schedule of construction events.

Shop Drawings, Product Data, Samples and other Submittals are not part of the Contract. Their purpose is to demonstrate, for those portions of the Work for which Submittals are required, the way the Contractor proposes to conform to the requirements of the Contract and the design concept expressed in the Contract.

The Contractor shall review, approve and submit to the Owner all Shop Drawings, Product Data, Samples and other Submittals required by the Contract regardless of whether the document originated with the Contractor or with some other Subcontractor or supplier. They shall be submitted at the time required by the Contract, or, if no time is specified, with reasonable promptness and in such sequence as to cause no delay in the Work or in the activities of the Owner or of separate Contractors. Submittals made by the Contractor that are not required by the Contract may be returned without action or may not be returned at all.

Informational Submittals that do not require the Owner to take responsive action may be so identified in the Contract.

The Contractor shall submit electronically a copy of any Submittal required by the Contract or when requested by the Owner's Representative. In addition, the Contract may also require the Contractor to provide information about the products and materials it proposes to incorporate into the Work and to provide samples of such products and materials for inspection or testing. The Contractor shall be responsible for all Submittals presented to the Owner for review, no matter what their point of origin may have been.

The Contractor shall not perform a portion of the Work that requires the Owner to review a Submittal until the respective Submittal has been reviewed by the Owner as outlined below. Such work shall be performed in accordance with Submittals that conform to the Contract Documents.

When tendering a Submittal to the Owner for review, the Contractor represents that it has determined and verified materials, field measurements and field construction criteria related thereto, or will do so, and has checked and coordinated the information contained with such Submittals with the requirements of the Work and of the Contract. The Contractor shall expressly note where any submittal differs from or varies from the requirements of the Contract, notwithstanding any belief on the part of the Contractor that the variance is obvious.

The Owner's review of any Submittal does not relieve the Contractor from its responsibility to follow the requirements of the Contract. The Owner is not responsible for ensuring that Submittals are correct. Failure of the Owner to discover that a submittal varies from the requirements of the Contract Documents does not relieve the Contractor of its responsibilities to conform to the Contract nor provide a basis for a Change Order. Nevertheless, the Owner's Representative shall review any Submittals provided in order to make a general determination about whether they appear to meet Contract requirements or the intended design of the Project. The Contractor remains responsible for following the Contract, including, but not limited to:

- Confirming and correlating all dimensions.
- Fabricating and construction techniques.
- Coordinating the work with that of all other trades and Subcontractors.
- Satisfactorily performing the Work in strict accordance with the Contract Documents.

- The means and methods of construction.
- Conforming to all the requirements of the Contract.

The Owner's Representative shall have fourteen (14) days to review any Submittals. Submittals returned to the Contractor as "REVISE AND RESUBMIT" OR "REJECTED" and subsequently resubmitted shall have fourteen (14) days for each additional review. The Owner's Representative will review the Submittals and return them electronically to the Contractor stamped with one of the following notations:

- "NO EXCEPTIONS TAKEN": If the Submittal is marked, "NO EXCEPTIONS TAKEN," this means that the Contractor immediately can begin the work encompassed by the Submittal.
- "MAKE CORRECTIONS NOTED": If the Submittal is marked "MAKE CORRECTIONS NOTED" the Contractor is required to make any revisions suggested by the Owner's Representative and, upon correction, may immediately begin the work indicated by the Submittal or may incorporate the material or equipment covered by the Submittal into the Work.
- "REVISE AND RESUBMIT": If the Submittal is marked "REVISE AND RESUBMIT," the Contractor is required to revise the Submittal and resubmit it to the Owner's Representative. No work shown on the Submittal, or which is dependent upon review of the Submittal or material or equipment covered by the Submittal, may be incorporated into the Work until the Contractor has made the necessary revisions, resubmitted the Submittal and received the Submittal back marked either "NO EXCEPTIONS TAKEN" or "MAKE CORRECTIONS NOTED."
- "REJECTED": If the Submittal is marked "REJECTED" it means that the Owner's Representative has found the Submittal, material or product data to be unacceptable and not in conformance with the Contract. Generally speaking, rejection of a Submittal simply indicates the Owner's Representative's belief that the defects in the Submittal are so great that it cannot be revised in order to make it conform to the Contract, as indicated in paragraph I (3) above. The Contractor may not begin work indicated by the Submittal, nor incorporate material or equipment, nor proceed with Work dependent upon review of the Submittal, into the Work based on any Submittal, product data or material that has been marked "REJECTED."

The following rules about Contract Time shall apply to Submittals. Contract Time will not be extended if:

- The Contractor's delay resulted from the Owner's use of the full amount of allotted time under the Contract to review the Contractor's Submittal;
- The Contractor's delay resulted from its own failure to provide a submittal in a timely manner;
- The Contractor's delay resulted from a submittal that properly was marked "Revise and Resubmit," "Rejected;" or
- The Contractor did not understand what it was required to submit and failed to inquire about it in a timely manner.

The Contractor shall keep a current schedule of submittals available for the Owner's Representative to review.

1.1.26 EXTRA WORK AND CONTRACTOR CHANGE ORDERS

Owner and Contractor mutually agree that changes in Plans, quantities, or details of the Work are inherent in the nature of construction and may be necessary or desirable. Therefore, without impairing the Contract, the Owner reserves the right to require changes determined necessary or desirable to complete the proposed construction within the general scope of the Work provided for in the Contract or to order Extra Work if that is required. Performance of changed or Extra Work shall be in accordance with requirements of the Contract.

When the Owner's Contract Administrator is contemplating changed or Extra Work, a Notice of the proposed changed or Extra Work together with a solicitation for a quotation for the performance of the changed or Extra Work shall be issued to the Contractor, in writing, by the Owner's Contract Administrator.

During construction, any change that the Contractor performs that varies from the approved Contract requires a change order submitted and approved by PGE prior to commencing work. A Contractor change order will require review by multiple PGE individuals and PGE will be allowed fourteen (14) days before the change order is approved or denied. A contractor's failure to notify PGE in advance of the change being performed will be denied for payment and time extensions.

During construction, the Contractors site Project Manager and the PGE Site Inspector will need to maintain regular discussions with the PGE engineering team. It is expected that changes that occur are addressed far enough ahead to not impact the overall project schedule. On-site weekly meetings discussing upcoming work should address possible change issues far in advance before a change order is submitted.

Contractor will be responsible to submit with the change orders all supporting e- mails and documentations supporting the change order request. Copies of all invoices from material suppliers are to be included with the change order to support costs outlined in a change order.

When preparing its Change Order, or when beginning any portion of the Work, the Contractor shall use the following order of precedence to resolve any Extra Work and Change Order requests:

For Change Orders for a Maximum of $5,000 Value:

- PGE Site Inspector can give verbal approval for the Contractor to proceed based on a follow-up written Change Order submittal by the Contractor.
- Contractor submits a Change Order request via SharePoint and also to the PGE Contract Administrator and CC's the PGE PM. The Change Order request will include supporting documentation, e-mails and material costs supporting the Change Order request cost. The Change Order submittal shall be no greater than 15 days from the change.

For Change Orders over $5,000 but No Change to Project Scope or Schedule:

- Contractor discusses the requirement for the Change Order with the PGE Site Inspector but does not proceed.

- Contractor submits a Request for Information (RFI) to PGE via the SharePoint site or requests technical support from PGE Engineering immediately or within 5 business days of Change Requirement.
- PGE will respond to the RFI or technical request to the Contractor within 5 business days after the RFI or technical request.
- Contractor submits the Change Order to the PGE Contract Administrator before proceeding. CC's the PGE PM. The Change Order request will include supporting documentation, e-mails and material costs supporting the Change Order costs. The Change Order submittal shall be no greater than 15 days from the original Contractor RFI or technical request from PGE. Greater than 15 days shall be allowed with a PGE approval per Change Order.
- PGE Contract Administrator, PGE Site Inspector, PGE PM and PGE Engineering discuss the Change Order.
- PGE Contract Administrator approves/denies the Change Order with PGE PM and PGE Engineering support.

For Change Orders to Revise the Project Scope - Regardless of Cost:

- Contractor discusses the requirement for the Scope Change/Change Order with the PGE Site Inspector but does not proceed on the work.
- Contractor requests information from PGE Engineering through an RFI submittal within 5 business days.
- PGE will respond to the RFI or technical request to the Contractor within 5 business days after the RFI or technical request.
- Contractor submits the Change Order to the PGE Contract Administrator before proceeding. CC's the PGE PM. The Change Order request will include supporting documentation, e-mails and material costs supporting the Change Order costs. The Change Order submittal shall be no greater than 15 days from the original Contractor RFI or technical request from PGE. Greater than 15 days shall be allowed with a PGE approval per Change Order.
- PGE Contract Administrator, PGE Site Inspector, PGE PM and PGE Engineering discuss the Scope Change.
- PGE Contract Administrator approves/denies the Change Order after PGE PM and PGE Engineering approval.

For Change Orders to Revise the Overall Project Schedule - Regardless of Cost:

- Contractor discusses the requirement for the Schedule Change with the PGE Site Inspector.
- Contractor discusses the schedule change with the PGE PM and the PGE Contract Administrator.
- PGE will respond to a schedule change request within 5 business days after the request.
- Contractor submits a Change Order for the Schedule change to the PGE Contract Administrator before proceeding. CC's the PGE PM. The Change Order request will include supporting documentation, e-mails and material costs supporting the Change. The Change Order shall be submitted no greater than 15 days from the original schedule discussions with PGE.
- PGE Contract Administrator, PGE Site Inspector, PGE PM and PGE

Engineering discuss the Schedule Change.

- PGE Contract Administrator approves/denies the Schedule Change on the Change Order after PGE PM and PGE Engineering approval.

1.1.27 DIFFERING SITE CONDITIONS

The Contractor shall promptly, and before the conditions are disturbed, give written Notice to the Owner's Representative of:

- Pre-existing subsurface or latent physical conditions at the site which differ materially from those indicated in this Contract, or;
- Pre-existing unknown physical conditions at the site, of an unusual nature, which differ materially from those ordinarily encountered and generally recognized as inherent in the work of the character provided for in the Contract.

After receipt of the Notice, the Owner's Representative will investigate the conditions encountered by the Contractor promptly. If the Representative finds that the conditions are materially different and cause a material increase or decrease in the Contractor's cost of, or the time required for, performing any part of the Work under this Contract, whether or not changed as a result of the conditions, an Equitable Adjustment to the Contract will be made under this clause and the Contract modified in writing accordingly. If possible, Owner and Contractor shall agree on the adjustment to be made. If they are unable to agree, the Representative will determine the amount of the Equitable Adjustment and adjust the time to perform if appropriate. If the Representative finds that differing site conditions do not exist, that decision is final and binding upon the Contractor.

Contractor has waived its right to bring a Claim for additional compensation or Contract Time for encountering a differing site condition unless the Contractor has given the Notice required by the Paragraph above. No request by the Contractor for an Equitable Adjustment to the Contract as a result of a differing site condition will be allowed if the request is made after Final Payment under this Contract.

1.1.28 AUTHORITY OF THE OWNER'S REPRESENTATIVE'S

The Work shall be performed to the complete satisfaction of the Owner's Field Inspector and Contract Administrator.

Work will not be considered completed until it has passed final inspection by the Owner's Field Inspector and is accepted by the Owner. The authority of the Owner's Field Inspector is such that the Contractor shall at all times carry out and fulfills the instructions and directions of the Owner's Representative's in so far as they concern the work to be done under the Contract.

The Owner's Contract Administrators decisions will be final, binding and conclusive on the Contractor on all questions that arise regarding the quantity of materials and work, the quality of materials and work, the acceptability of materials furnished and work performed, the acceptable rate of progress of the work, the interpretation of the Plans and Specifications, the measurement of all quantities, the acceptable fulfillment of the Contract on the part of the Contractor, and payments under the Contract.

If the Contractor fails to comply with any reasonable order made under the provisions of this Subsection, the Owner's Contract Administrator shall have the authority to cause unacceptable work to be remedied or removed and replaced, and unauthorized work to be removed, and to deduct the costs thereof from any money due or to become due the Contractor.

Nothing in this Subsection or elsewhere in the Contract shall be construed as requiring the Owner's Field Inspector and Contract Administrator to direct or advise the Contractor on the method or manner of performing any work under the Contract. No approval or advice as to the method or manner of performing or producing any materials to be furnished shall constitute a representation or warranty by the Owner that the result of such method or manner will conform to the Contract, relieve the Contractor of any of the risks or obligations under the Contract, or create any liability to the Owner because of such approval or advice.

An Architect, Engineer, Designer or other person hired or employed by Owner under a separate Contract is not the Owner's Field Inspector nor Contract Administrator, unless the Contract Documents expressly state otherwise.

Contractor will be notified if the Owner's Representatives have been changed.

The Owner's Field Inspector and Contract Administrator may assign Inspectors, assistants and other persons to advise the Owner whether the work and materials meet Contract requirements. Such determination may extend to any or all parts of the Work and to the preparation or manufacture of materials to be used.

In the event that assigned personnel discover defective materials or work not being performed safely or in accordance with Contract requirements, the Owner's Contract Administrator shall have the authority to reject the materials or to suspend the Work.

Assigned personnel, including but not limited to, Inspectors and assistants, are not authorized to approve or accept any portion of the Work, to accept materials, to issue instructions or to give advice that is contrary to the Contract. Work done or material furnished that does not meet Contract requirements shall be at the Contractor's risk, and does not provide a basis for a Claim even if it is asserted that assigned personnel changed Contract requirements.

In the event that assigned personnel or the Owner's Representatives fail to observe, call out or note faulty work, defective materials, errors, or the Contractor's failure to comply with Contract requirements, that failure does not constitute acceptance or approval of that particular portion of the Work. If this occurs, the Contractor remains obligated to perform the Work in accordance with the Contract Documents, without additional compensation or Contract Time.

The provisions of this Subsection do not apply to Regulatory Inspectors.

If any Owner's Representatives note faulty work, defective materials, errors or the Contractor's failure to comply with Contractor requirements, it will notify the Contractor's Representative.

1.1.29 Project Meeting Requirements

The Contractor shall provide an onsite location where at least bi weekly meetings (every other week) shall be held between PGE and the Contractor. PGE representatives will include the Project Manager, Contract Manager, Project Engineer, Site Inspector, and may include others. The meeting time and dates will be scheduled in advance and agreed to by both parties. The meetings will review project progress, discuss future work, and work out other outstanding issues.

1.1.30 Progress Reports

Weekly progress reports will be provided by the Contractor to the Project Manager and Contract Manager.

2 Site Work

6. SECTION 2100 Erosion and Sediment Control Plan (ESCP) and NPDES Stormwater Discharge Permits (1200-C or 1200-CN)

2.1.1 General

2.1.2 Scope

The work covered by this specification includes: furnishing of all labor, equipment and materials required for creating and providing an Erosion and Sediment Control Plan (ESCP) and submittal for a 1200-C or 1200-CN permit.

Prior to commencement of any land disturbing activities greater than one acre (>1 acre or as stipulated), Contractor (or Owner) shall obtain a 1200-C or 1200-CN erosion control permit as required by the Department of Environmental Quality (DEQ) or its local agent. A copy of the approved permit and associated documents shall be kept onsite at all times and properly maintained and updated.

Contractor shall adhere to the Best Management Practices (BMP's) as indicated in the Erosion and Sediment Control Plan (ESCP). If at any time during construction the Contractor encounters or exposes any abnormal condition, which indicates the presence of a hazardous material, toxic or hazardous waste, work shall be immediately suspended and the Owner notified. Work in the affected areas shall not resume until so directed by the Owner.

2.1.3 Submittals

A. All 1200-C or 1200-CN documents (application, action plan, ESCP plan and /or drawings, narratives, inspection forms, etc.) shall be kept in a 3- ring binder or booklet as a minimum. Documents shall meet all requirements by the Oregon DEQ and/or local municipalities.
B. Contractor shall submit all necessary application forms, drawings, and other

required documents to Owner for review prior to submitting to DEQ.

2.1.4 Additional Information and Links

Information regarding application process and required submittals can be found at the Oregon Department of Environmental Quality NPDES Stormwater Discharge Permits – Construction Activities website:

http://www.deq.state.or.us/wq/stormwater/construction.htm

7. SECTION 2110 CLEARING & GRUBBING

2.1.5 General

2.1.6 Scope

The work covered by this specification includes: furnishing of all labor, equipment and materials required for clearing, grubbing, removal, and disposal of all rocks, trees, vegetation, rubbish, refuse trash and debris within the grading limits of the site, including access roads, drainage ditches, and other designated areas as shown on the drawings or specified herein.

2.1.7 Execution

Prior to commencement of any land disturbing activities greater than one acre (>1 acre or as stipulated), Contractor (or Owner) shall obtain a 1200-C or 1200-CN erosion control permit to be posted on site (refer to Section 2100). Contractor shall adhere to the Best Management Practices (BMP's) as indicated in the Erosion and Sediment Control Plan (ESCP). If at any time during construction the Contractor encounters or exposes any abnormal condition, which indicates the presence of a hazardous material, toxic or hazardous waste, work shall be immediately suspended and the Owner notified. Work in the affected areas shall not resume until so directed by the Owner.

Clearing: Contractor shall remove and dispose of trees, stumps, logs, limbs, sticks, vegetation, rubbish, debris, and other material on the natural ground surface. All areas within the designated grading limits or as required for access to the site or other purposes shall be cleared.

Grubbing: Contractor shall completely remove and dispose of roots, stumps, buried logs, debris, rocks and other materials that protrude through the surface within the site grading and site access limits.

All debris shall be disposed off-site by the Contractor.

Off-site disposal of debris shall be completed according to prevailing laws, ordinances, regulations, and rules, and at no additional cost to the Owner. The Contractor shall have on file a copy of the disposal permits or agreements.

8. SECTION 2120 SITE GRADING

2.1.8 General

2.1.9 Scope:

The work covered by this specification includes: furnishing labor, equipment and materials required for removal of topsoil, cutting, grading, filling, rough contouring, and compacting materials as required to establish the subgrade elevations for the site including interior and exterior access roads as shown on the drawings and specified herein.

2.1.10 CODES AND STANDARDS

Comply with the provisions of the following codes, specifications and standards, except as otherwise shown or specified. The latest edition of the code or standard shall govern.

AASHTO T 27	Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates
AASHTO T 176	Standard Method of Test for Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
AASHTO T 180	Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop
ASTM D 698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft- lbf/ft3 (600 kN-m/m3))
ASTM D 1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft- lbf/ft3 (2,700 kN-m/m3))
ASTM D 1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 6938	Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

Oregon Department of Environmental Quality (DEQ)

Environmental Protection Agency (EPA)

National Pollution Discharge Elimination System (NPDES)

Occupation Safety and Health Administration (OSHA)

2.1.11 SUBMITTALS

A. Contractor shall submit:

1. Aggregate suitability using a gradation (AASHTO T 27) and sand equivalent (AASHTO T 176), within the gradation limit as stated in section 2.0.
2. Maximum dry density and optimum moisture content. Refer to ASTM D 1557, D 698, AASHTO T 180, Method D.
3. Name of supplier, date sampled and location of source.

All imported fill material shall be submitted to the Owner for review and approval prior to placing any material. The Contractor shall verify that the aggregate and fill material meets Geotechnical engineering and state specifications.

2.1.12 MATERIALS

A General

Materials used for construction of embankments as shown on the drawings shall comply with the following:

i FILL TYPE RG-1 [In-Situ]: Re-use excavated and native material, as recommended in the Geotechnical Report and drawings. If a Geotechnical Report is not available, existing soil may be used for backfill if approved by Owner representative. Backfill shall be unsaturated, free of clay lumps, deleterious materials or stones larger than two inches in greatest dimension. Inorganic or organic silts, clays and peat soil types (ASTM soil group symbol ML, CL, MH, CH, OL, OH and PT) are not suitable for backfill. No frozen material shall be used as backfill.

ii FILL TYPE RG-2 [Imported Fill]: Imported fill free of friable material and debris; graded in accordance with ASTM T 27; within the following limits:

A. Gradation (per AASHTO T 27)

Sieve Size	Percent Passing
4 inch	100
3 inch	88 to 100
¾ inch	70 to 90
No. 10	40 to 60
No. 40	20 to 40
No. 200	less than

B. Sand Equivalent: 30 minimum per AASHTO T 176

iii Road Finish Rock: Imported fill consisting of untreated base course material meeting state Department of Transportation (DOT) requirements. Also refer to Section 2170 – Road Finish Rock

iv Aggregate Base Course: Imported fill as specified in Section 2150

2.1.13 EXECUTION

A Construction Layout and Surveying

Contractor shall provide all surveying work as required to maintain the lines, grades, and elevations required and shown on the drawings. Contractor shall set up temporary north-south and east-west base line markers outside the area to be graded so they will not be disturbed. Contractor shall set necessary cut and fill stakes. Before any earthwork, Owner shall approve all markers and stake locations.

After grading, Contractor shall establish and maintain horizontal and vertical references for locating all structures, fence lines and station equipment during construction.

Survey precision; for purposes of grading, elevations shall be within 0.1 feet and 0.01 feet for top of foundations and markers. Horizontal precision shall be sufficient to insure ease of erection of structures and placement of station equipment.

Contractor shall establish five permanent base line markers after station surfacing is complete. Markers shall be steel pins (rebar) extending below frost depth. The marker at the intersection of the lines shall be set about three inches below finished grade. The remaining four markers shall be set on the line, approximately three feet inside the fence. All markers shall be punched marked where the lines cross.

B Excavation

Prior to commencement of any land disturbing activities greater than one acre (>1 acre or as stipulated), Contractor (or Owner) shall obtain a 1200-C or 1200-CN erosion control permit to be posted on site (refer to Section 2100). Contractor shall adhere to the Best Management Practices (BMP’s) as indicated in the Erosion and Sediment Control Plan (ESCP). If at any time during construction the Contractor encounters or exposes any abnormal condition, which indicates the presence of a hazardous material, toxic or hazardous waste, work shall be immediately suspended and the Owner notified. Work in the affected areas shall not resume until so directed by the Owner.

Excavation work shall include the removal and subsequent handling of all soil materials excavated or otherwise removed in performance of excavation work. Contractor shall provide adequate protection of excavated side slopes as recommended by Occupation Safety and Health Administration (OSHA) and the Geotechnical Report to protect all personnel and to prevent "sloughing or cave in" into the work area.

Topsoil material removed is deemed "unsuitable" for use in embankments or as a subbase for roads or substation subgrade. Contractor shall excavate the unsuitable material to the depth shown on the drawings and haul to an off-site disposal location. Location of a suitable disposal site is Contractor's responsibility.

After completion of topsoil removal, Contractor shall excavate to establish subgrade elevations in "cut" areas of the site. Excess excavated material not used in embankment shall be removed from the site and disposed of by the Contractor. The Contractor shall meet the recommendations in the Geotechnical Report and Drawings.

C Embankment

Embankment shall consist of the construction of fills and placing of miscellaneous backfills, to the lines, grades, dimensions and typical sections shown on the plans and according to the Geotechnical Report.

All embankments shall be constructed from material type (**RG-1 and RG-2**) as defined above.

When constructing embankments on existing slopes, slopes shall be benched to ½ horizontal to 1 vertical (1/2H: 1V) prior to placement of fill material.

If it should become necessary, because of weather or other conditions, to suspend grading operations, the entire area worked upon shall be bladed until smooth, free of depressions, and ruts, and crowned so that no water can collect or be impounded.

Embankment material shall be placed in uniform layers not to exceed nine (9) inches in loose thickness, for the entire width of the embankment. Each layer of embankment shall be completed, leveled and uniformly compacted before the succeeding layer is placed. Water shall be added or removed, as necessary, in order to obtain the required density. Each lift shall be conditioned to near optimum moisture content and compacted to a density equivalent to at least ninety-five (95%) or ninety-eight (98%) percent of the maximum dry density obtainable by the ASTM D 1557 or ASTM D 698 respectively or as recommended in the Geotechnical Report. In-place field density shall be measured in accordance with ASTM D 1556 (sand cone) or ASTM D 6938 (nuclear gauge).

D Road Finish Rock

Road Finish Rock consists of installation of untreated road base material on areas designated on the drawings for roadways or parking. Prior to placing road finish rock materials, the subgrade shall be proof rolled with a fully loaded dump truck or similar equipment. Areas that pump or significantly deflect shall be over excavated as required and the material replaced with Road Finish Rock. Refer to Section 2170 – Road Finish Rock for placement and compaction.

E Aggregate Base Course

Aggregate Base Course material shall be placed on areas designated on the drawings. Prior to placing Aggregate Base Course materials, the subgrade shall be proof rolled with a fully loaded dump truck or similar equipment.

Areas that pump or significantly deflect shall be over excavated as required by the Geotechnical Report and replaced with Aggregate Base Course.

Refer to Section 2150 – Aggregate Base Course for placement and compaction.

9. SECTION 2130 GENERAL EXCAVATION & BACKFILL

2.1.14 GENERAL

2.1.15 SCOPE

This section covers the backfill and compaction of excavations for footings, foundations, and other miscellaneous facilities. Included are specifications for excavation, compaction and backfill materials. Contractor shall review appropriate drawings for the following typical installations:

A. General Backfill and Compaction:
Backfill and compaction required to bring low areas, miscellaneous excavation work, and replace soft spots to required contours and elevations.

B. Structural Backfill and Compaction:
Backfill and compaction required to restore the grade around footings, foundation walls, retaining walls, slab and pier foundations to required contours and elevations.

C. Roadway Backfill and Compaction:
Backfill and compaction for the installation of access roads, substation interior roads and parking areas to required contours and elevations

2.1.16 Codes and Standards

AASHTO T 180	Moisture-Density Relations of Soils Using a 10-lb (4.54- kg) Rammer and an 18-in. (457-mm) Drop
ASTM C33:	Standard Specification for Concrete Aggregates ASTM C136: Method for Sieve Analysis of Fine and Coarse Aggregates.
ASTM D 698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft- lbf/ft3 (600 kN-m/m3))
ASTM D 1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft- lbf/ft3 (2,700 kN-m/m3))
ASTM D 1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 6938	Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

2.1.17 Submittals:

Contractor shall submit gradation test results per ASTM C136 and moisture- density relationships per ASTM D698, D1557 or AASHTO T180 to the Owner for approval for <u>all</u> imported aggregate materials two weeks prior to start of backfilling.

2.1.18 Field Measurements:

Contractor shall verify that survey benchmark and intended elevations for the work are as shown on drawings. Locate all underground utilities prior to starting excavation work.

2.1.19 Information Supplied by Owner:

Contractor shall obtain a copy of the Geotechnical Report which shall provide site specific geotechnical recommendations. If a Geotechnical Report is not available, the Owner will determine if existing soils are suitable for use as backfill.

2.1.20 Materials

A *Fill Materials: as specified in Section 2120, Paragraph 2.0 (Materials) above.*

2.1.21 Execution

A Preparation

i Prior to commencement of any land disturbing activities greater than one acre (>1 acre or as stipulated), Contractor (or Owner) shall obtain a 1200-C or 1200-CN erosion control permit to be posted on site (refer to Section 2100). Contractor shall adhere to the Best Management Practices (BMP's) as indicated in the Erosion and Sediment Control Plan (ESCP). If at any time during construction the Contractor encounters or exposes any abnormal condition, which indicates the presence of a hazardous material, toxic or hazardous waste, work shall be immediately suspended and the Owner notified. Work in the affected areas shall not resume until so directed by the Owner.

ii Identify required lines, levels, contours, and datum.

iii Protect plant life, lawns, and other features remaining as a portion of final landscaping.

iv Protect bench marks, existing structures, foundations, fences, sidewalks, paving, and curbs from excavation equipment and vehicular traffic.

v Maintain and protect existing above and below grade utilities.

vi Over excavate and remove any unsuitable soft native soils. Backfill as recommended in the Geotechnical Report. If a Geotechnical Report is not available backfill with Road Finish Rock as defined in Section 2170. Road Finish Rock shall be conditioned to within +/- 2% of optimum moisture and compacted to at least 95% of the maximum dry density according to ASTM D 1557 or 98% of the maximum dry density according to ASTM D 698.

2.1.22 EXCAVATION

A Excavate subsurface soils as required for the installation of the work per the drawings.

B Do not interfere with the bearing splay of existing foundations, about 45o from the foundation base.

C Manually remove loose, lumped or frozen subsoil, boulders, rock greater than three (3") inches in diameter and other deleterious matter.

D Correct areas over excavated under the direction of the Geotechnical Engineer or Owner Engineer.

E Stockpile excavated material in an area where they will not contaminate other soils or Yard Finish Rock. If excavated soil is suitable for backfilling, designate an area within the construction limits and remove excess material not being used, from the site.

2.1.23 BACKFILL

A *Backfill in accordance with the typical cross-sections, contours and elevations as shown on the drawings. Backfill materials shall be placed without frozen lumps, snow or entrained ice.*

B *Do not backfill over porous, wet, frozen or spongy subgrade surfaces. Correct these areas under the direction of the Geotechnical Engineer or Owner Engineer.*

C *Employ a placement method that does not disturb or damage existing foundations, utilities, conduit duct, cable or wire. Backfill simultaneously on each side of unsupported foundation walls until support is in place.*

D *Condition soil to be used as backfill within +/- 2% optimum moisture content. Properly place backfill materials in (9") nine-inch loose horizontal lifts and compact as shown on the drawings. Each lift shall be compacted to at least 95% of maximum dry density per ASTM D 1557 modified.*

E *Contractor shall notify Owner prior to any backfill operation so equipment and intended compaction methods can be reviewed for approval by Owner.*

2.1.24 TOLERANCES

The top surface of backfilling shall match surrounding grade after compaction. Yard or Road Finish Rock shall be applied after completion of backfill work as required by drawings. Refer to Section 2160, Yard Finish Rock and Section 2170, Road Finish Rock.

2.1.25 FIELD QUALITY CONTROL

Owner shall hire an approved independent testing agency to perform compaction tests accordance ASTM D 6938. Work not meeting specified requirements shall be removed, replaced, compacted, and retested at the Contractors expense.

Test frequency shall be a minimum of one test per two-hundred (200 square feet (surface) or as determined by the Geotechnical Report or Owner Engineer.

Testing agency shall meet laboratory requirements according to ASTM and be certified in both AASHTO Materials Reference Laboratory (AMRL) and Cement and Concrete Reference Laboratory (CCRL).

2.1.26 PROTECTION OF FINISHED WORK

Contractor shall protect footings, foundation walls, piers, flat foundations, and embedded anchor bolts as required to prevent damage during backfill and compaction work.

10. SECTION 2140 TRENCH EXCAVATION & BACKFILL

2.1.27 GENERAL

2.1.28 SCOPE

This section covers the installation of electrical utilities, piping, conduits, culverts and other underground facilities. Included are specifications for excavation, compaction, bedding and backfill materials. Methods for excavation, placement of the utility and backfill differ for each utility installed and on-site conditions. Contractor shall review appropriate drawings for typical installed trench cross sections.

In general, they are as follows:

A. Grounding: Main ground girds are placed in narrow trenches and at termination and crossing points in wider excavations. Trenches are backfilled with in-situ soils only.

B. Conduit Banks: Conduit banks are placed in trenches either singularly or in groups. Main runs are placed on a sand bed and covered with a layer of sand, fluidized thermal backfill, red concrete, or red control density fill.

D. Culverts and Underground Piping: Culverts and piping installations vary and are specified in the drawings.

Contractor shall furnish all material, labor, tools and equipment necessary to install utilities as shown on the drawings and as specified herein.

2.1.29 CODES AND STANDARDS

Comply with the provisions of the following codes, specifications and standards, except as otherwise shown or specified. The latest edition of the code or standard shall govern.

American Society of Testing and Materials (ASTM)

ASTM C 33	Standard Specification for Concrete Aggregates
ASTM C 136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D 698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft- lbf/ft3 (600 kN-m/m3))
ASTM D 1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft- lbf/ft^3 (2,700 kN-m/m^3))
ASTM D 1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 6938	Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

2.1.30 SUBMITTALS

Contractor shall submit gradation test results per ASTM C 136 and moisture- density relationships per ASTM D 698 or D 1557 to the Owner for approval for all imported aggregate materials two weeks prior to start of backfilling.

2.1.31 FIELD MEASUREMENTS

Contractor shall verify that survey benchmark and intended elevations for the Work are as shown on drawings. Locate all underground utilities before starting excavation work.

2.1.32 COORDINATION

Contractor shall coordinate all substation work and verify work associated with lower elevation utilities is complete before placing higher elevation utilities.

2.1.33 Information Supplied by Owner

Contractor shall obtain a copy of the Geotechnical Report which shall provide site specific geotechnical recommendations. If a Geotechnical Report is not available, the Owner will determine if existing soils are suitable for use as backfill.

2.1.34 Materials

A Fill Materials

i Soil Fill Type [In-situ]: Re-use excavated and/or native material as recommended in the Geotechnical Report and drawings. If a Geotechnical Report is not available, soil may be used for backfill if approved by Owner representative. Backfill shall be unsaturated, free of clay lumps, deleterious materials or stones larger than four inches in greatest dimension. Inorganic or organic silts, clays and peat soil types (ASTM soil group symbol ML, CL, MH, CH, OL, OH and PT) are not suitable for backfill. No frozen material shall be used as backfill.

ii Aggregate Base Course: As specified in Section 2150

iii Aggregate Surfacing – Road Finish Rock: As specified in Section 2170

iv Concrete: Structural concrete conforming to Section 3000 with a minimum compressive strength of 4,000 psi, unless otherwise specified by Geotechnical engineer.

v E Controlled Density Fill: As specified in Section 3010

2.1.35 Execution

A Preparation

i Prior to commencement of any land disturbing activities greater than one acre (>1 acre), If required, Contractor shall obtain a Storm Water Pollution Prevention Plan (SWPPP) General Permit or Notice of Intent (NOI) to be posted on site. Contractor shall adhere to the Best Management Practices (BMP's) as indicated in the SWPPP.

ii Identify required lines, levels, contours, and datum.

iii Protect plants, lawns, and other features remaining as a portion of final landscaping.

iv Protect benchmarks, structures, foundations, fences, sidewalks, paving, and curbs from excavation equipment and vehicular traffic.

v Maintain and protect above and below grade utilities which are to remain.

vi Over excavate and remove any unsuitable soft native soils. Backfill as recommended in the Geotechnical Report. If a Geotechnical Report is not available, reference table 1 for appropriate backfill.

2.1.36 EXCAVATION

A Contractor shall provide adequate protection of excavated side slopes as recommended by Occupation Safety and Health Administration (OSHA) and the Geotechnical Report to protect all personnel and to prevent "sloughing or cave in" into the work area.

B Excavate trenches sufficiently wide to enable installation of utilities and allow room for inspection. Trench widths shall be kept to a minimum to allow sufficient space for equipment installation.

C Excavations shall not interfere with the bearing splay of foundations, about 45o from the foundation base.

D Manually remove loose, lumped or frozen subsoil, boulders, rock greater than two (2") inches in diameter and other deleterious matter.

E Correct areas over excavated under the direction of the Geotechnical Engineer or Owner Engineer.

F Stockpile excavated material in an area where they will not contaminate other soils or Yard Finish Rock. If excavated soil is suitable for backfilling, designate an area within the construction limits and remove excess material not being used, from the site.

G Blasting shall not be utilized for excavation of the trenched areas.

2.1.37 BACKFILLING

A Backfill trenches in accordance with the typical cross sections, contours and elevations shown on the drawings. Backfill materials, listed above, shall be placed without frozen lumps, snow or entrained ice.

B Do not backfill over porous, wet, frozen or spongy subgrade surfaces. Correct these areas under the direction of the Geotechnical Engineer or Owner Engineer.

C Employ a placement method that does not disturb or damage conduit duct, cable or wire in trench.

D Condition soil to be used as backfill within +/- 2% optimum moisture content. Properly place backfill materials in (9") nine-inch loose horizontal lifts and compacted to the required density shown in table

E Contractor shall notify Owner before any backfill operation so equipment and intended compaction methods can be reviewed for approval by Owner.

F At some locations, as shown on the drawings, a red concrete protective cap, or warning tape shall be installed over the cover backfill. Refer to construction drawings.

2.1.38 TOLERANCES

The top surface of backfilling shall match surrounding grade after compaction. Yard Finish Rock shall be applied after completion of backfill work as required by drawings.

Trenches for duct banks shall be excavated to lines indicated on the drawings or at other locations acceptable to the Owner Engineer and to within ½ of depth required.

2.1.39 FIELD QUALITY CONTROL

Owner shall hire an independent testing agency to perform compaction tests accordance ASTM D 6938. Work not meeting specified requirements shall be removed, replaced, compacted, and retested at the Contractors expense.

Test frequency shall be a minimum of one for every 50 lf of trench installed or as determined by the Geotechnical Engineer.

2.1.40 PROTECTION OF FINISHED WORK

Contractor shall provide adequate protection of excavated side slopes as recommended by Occupation Safety and Health Administration (OSHA) and the Geotechnical Report to protect all personnel and to prevent "sloughing or cave in" into the work area. Removed soil from the excavation shall be stored away from the trench to avoid sloughing into the trench. Protection from freezing and water accumulation shall be provided for the bottom of excavations and soil adjacent to and beneath adjacent foundations.

Table 1

Materials, Compaction, and Testing Requirements

Material	Gradation Requirements	Plasticity Require-ments	Maximum Density	Maximum Density Test Frequenc	Required Field Density	Field Density Test	Frequency	Field Water Content	Field Water Content Test	Lift Thick-ness	Remarks
Trench subgrades	-	-								-	Trench subgrades shall be firm, dense, free from mud, and sufficiently
30 inch pipe or smaller Crushed rock or crushed gravel embedment	Perform at least two gradation tests; at least 95% passing 1/2" sieve and not more than 5% passing No. 4 sieve	Nonplastic	ASTM D4253 and ASTM D4254	2 initial tests; further tests as directed	70% Relative Density	ASTM D6938; and ASTM D1556 or ASTM D2167 (10% of tests to be ASTM D1556 or ASTM D2167)	One test per 100 feet of trench for each lift	-	-	9" max	Minimum 4 passes with a vibratory flat plate tamper
Sand embedment	Perform at least two gradation tests; at least 95% passing No. 4 sieve and not more than 5% passing No. 100 sieve	Nonplastic	ASTM D698, Method C	2 initial tests; further tests as directed	95% Max. Dry Density	ASTM D6938; and ASTM D1556 or ASTM D2167 (10% of tests to be ASTM D1556 or ASTM D2167)	One test per 100 feet of trench for each lift	-	-	9" max	Clean sand

Groundwater barrier	-	Cohesive material (Soil Classifi-cation GC, SC, CL, or ML as indicated in ASTM D2487, Table 1	ASTM D698, Method C	2 initial tests; further tests as directed	95% Max. Dry Density	ASTM D6938; and ASTM D1556 or ASTM D2167 (10% of tests to be ASTM D1556 or ASTM D2167)	One test for each groundwater barrier	-2% to +2% of optimum water content	ASTM D6938; ASTM D1556 or ASTM D2167 (10% of tests to be ASTM D1556 or ASTM D 2167)	9" max	Material may be finely divided suitable job excavated material, free from stones, organic matter, and debris

Table 1 Materials, Compaction, and Testing Requirements											
Material	**Gradation Requirements**	**Plasticity Require-ments**	**Maximum Density**	**Maximum Density Test**	**Required Field Density**	**Field Density Test**	**Frequency**	**Field Water Conte**	**Field Water Content Test**	**Lift Thicknes s**	**Remarks**
Trench backfill	2" max particle size	LL < 40 PI < 15	ASTM 698, Method C	2 initial tests; further tests as directed	90% Max Dry Density	ASTM D6938; and ASTM D1556 or ASTM D2167 (10% of tests to be ASTM D1556 or ASTM D2167)	One test per 50 feet of trench for each lift	-2% to +2% of optimu m water content	ASTM D6938; ASTM D1556 or ASTM D2167 (10% of tests to be ASTM D 1556 or ASTM D	9" max	-
Trench backfill traversing subgrades of streets, roads, railroads, parking areas, undergroun d piping, undergroun d electrical ducts and conduit, and other facilities subject to damage by settlement	3" max particle size	-	ASTM D698, Method C	2 initial tests; further tests as directed	95% Max Dry Density	ASTM D6938; and ASTM D1556 or ASTM D2167 (10% of tests to be ASTM D1556 or ASTM D2167)	One test per 100 feet of trench for each lift	-2% to +2% of optimu m water content	ASTM D6938; ASTM D1556 or ASTM D2167 (10% of tests to be ASTM D1556 or ASATM D2167)	9" max	

11. SECTION 2150 AGGREGATE BASE COURSE

2.1.41 GENERAL

2.1.42 SCOPE

The work covered by this specification includes furnishing of all labor, equipment and materials required for placement of Aggregate Base Course as shown on the drawings, geotechnical report, and specified herein.

2.1.43 CODES AND STANDARDS

Comply with the provisions of the following codes, specifications and standards, except as otherwise shown or specified. The latest edition of the code or standard shall govern.

AASHTO T 27	Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates
AASHTO T 176	Standard Method of Test for Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
AASHTO T 180	Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop
ASTM D 698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft- lbf/ft3 (600 kN-m/m3))
ASTM D 1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft- lbf/ft^3 (2,700 kN-m/m^3))
ASTM D 1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 6938	Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

2.1.44 SUBMITTALS

A *Contractor shall submit:*

i Aggregate suitability using a gradation (AASHTO T 27) and sand equivalent (AASHTO T 176), within the gradation limit as stated in section 2.0.

ii Maximum dry density and optimum moisture content. Refer to

iii ASTM D 1557, D 698, and AASHTO T 180, Method D.

iv Name of supplier, date sampled and location of source.

All imported fill material shall be submitted to the Owner for review and approval prior to placing any material. The Contractor shall verify that the aggregate and fill material meets Geotechnical Engineering and state specifications.

2.1.45 MATERIALS

Aggregate Base Course material shall be sound, hard, durable crushed rock uniformly graded from coarse to fine. The aggregate shall conform to the following specifications unless otherwise approved by Owner.

A. Gradation (per AASHTO T 27)

Sieve Size	Per Cent Passing
3”	100
2-½”	85-100
1-¼”	55-75
3/8”	30-45
#10	15-25
#40	10-20
#200	0-7

A. Sand Equivalent (per AASHTO T 176) Minimum of 30

B. Fractured Face
Provide at least one mechanically fractured face for a minimum of 50% of particles retained on the #4 US Standard size sieve.

2.1.46 EXECUTION

Aggregate Base Course material shall be placed on areas designated on the drawings. Prior to placing Aggregate Base Course materials, the subgrade shall be proof rolled with a fully loaded dump truck or similar equipment.

Areas that pump or significantly deflect shall be over excavated as required by the Geotechnical Report and replaced with Aggregate Base Course.

Aggregate Base Course material shall be placed in uniform layers not to exceed (9) nine inches in loose thickness, for the entire width of the surface. Each layer of Aggregate Base Course shall be completed, leveled and uniformly compacted before the succeeding layer is placed. Water shall be added or removed, as necessary, in order to obtain the required density.

Each lift shall be conditioned to +/- 2% of the optimum moisture content and compacted to a density at a minimum of ninety-five (95%) percent of the maximum dry density according to ASTM D1557modified, ninety-eight (98%) percent of the maximum dry density according to ASTM D 698, standard or as recommended by the Geotechnical Engineer. In place, field density shall be verified in accordance with ASTM D 1556 or ASTM D 6938.

Project Substation footprint, including those areas reserved for future build-out, plus a minimum of three (3) feet outside the perimeter fence, to help reduce touch and step potentials. A greater level of washed crushed aggregate shall be installed if necessary to meet the Requirements and satisfy the recommendations set forth in the Geotechnical Report.

12. SECTION 2160 YARD FINISH ROCK

2.1.47 GENERAL

2.1.48 SCOPE

The work covered by this specification includes furnishing of all labor, equipment and materials required for placement of Yard Finish Rock as shown on the drawings and specified herein.

Yard Finish Rock shall meet the criteria in section 2.0.

2.1.49 CODES AND STANDARDS

Comply with the provisions of the following codes, specifications and standards, except as otherwise shown or specified. The latest edition of the code or standard shall govern.

American Association of State Highway and Transportation Officials (AASHTO)

AASHTO T 27 Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates

AASHTO TP 61 Determining the Percent of Fracture in Coarse Aggregate American Society of

Testing and Materials Standards (ASTM)

ASTM D 5821 Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate

2.1.50 SUBMITTALS

A. Contractor shall submit:
1. Aggregate suitability using a gradation (AASHTO T 27) within the gradation limit as stated in section 2.0.
2. Name of supplier, date sampled and location of source.
3. Five-gallon bucket sample of proposed yard finish rock to the Owner for testing.

Sample shall be submitted to the Owner for review, testing, and approval prior to placing any material.

2.1.51 MATERIALS

Yard Finish Rock used to surface the substation yard as shown on the drawings shall be sound, hard, durable, clean angular crushed rock.

The rock shall meet the following criteria:

A. Sieve Analysis (per AASHTO T27)

Sieve Size	Percent Passing By
1½"	100
1"	20-85
¾" *	0-30
⅝" *	0-30
1/4"	0-5

*Material must meet either the ¾-inch or ⅝-inch sieve requirement, but not both.

B. Rock Quality (per AASHTO TP 61, or ASTM D 5821)
Fractured Faces: At least one mechanically fractured face on 95% of all particles retained on each sieve 1/4-inch and above. In addition, at least three mechanically fractured faces on 70% of the same particles.

C. Rock Resistivity
A minimum wet resistivity of 3,000 ohm-m is required for all Yard Finish Rock.

2.1.52 EXECUTION

Yard Finish Rock shall be evenly spread and roller compacted on the designated areas of the yard as shown on the drawings. Final depth of Yard Finish Rock shall be four inches (4") or as shown on the drawings.

Subgrade layer shall be prepared per section 2130 General Excavation & Backfill. Surface of Yard Finish Rock shall be free from corrugations or waves. Areas at the Project Substation to be surfaced with finish rock, including areas outside the permanent fence, shall be treated with a weed eradicator and soil fumigant. Care shall be taken with the application of the soil sterilant to prevent contamination of adjacent areas.

13. SECTION 2170 ROAD FINISH ROCK

2.1.53 GENERAL

2.1.54 SCOPE

The work covered by this specification includes furnishing of all labor, equipment and materials required for placement of Road Finish Rock as shown on the drawings and specified herein.

2.1.55 CODES AND STANDARDS

Comply with the provisions of the following codes, specifications and standards, except as otherwise shown or specified. The latest edition of the code or standard shall govern.

AASHTO T 27	Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates
AASHTO T 176	Standard Method of Test for Plastic Fines in Graded

	Aggregates and Soils by Use of the Sand Equivalent Test
AASHTO T 180	Standard Method of Test for Moisture-Density of Soils Using a 4.54-kg (10-lb) Rammer and a 457-(18-in.) Drop
AASHTO T 89	Standard Method of Test for Determining the Liquid Limit of Soils
AASHTO T 90	Standard Method of Test for Determining the Plastic Limit and Plasticity Index of Soils
ASTM D 698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3))
ASTM D 1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3))
ASTM D 1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 6938	Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

2.1.56 SUBMITTALS

A. Contractor shall submit:

1. Aggregate suitability using a gradation (AASHTO T 27) and sand equivalent (AASHTO T 176), within the gradation limit as stated in section 2.0.
2. Maximum dry density and optimum moisture content. Refer to ASTM D 1557, D 698, AASHTO T 180, Method D.
3. Name of supplier, date sampled and location of source.

All imported fill material shall be submitted to the Owner for review and approval prior to placing any material. The Contractor shall verify that the aggregate and fill material meets Geotechnical engineering and state specifications.

2.1.57 MATERIALS

Road Finish Rock material shall be sound, hard, durable, crushed rock uniformly graded from coarse to fine. The Road Finish Rock shall conform to the following specifications unless otherwise approved by Owner.

A. Gradation (per AASHTO T 27)
Percent passing based on total aggregate (dry weight), and fine and coarse aggregate having approximately the same bulk specific gravities.

Sieve Size	Percent
1-½"	100
1"	90 - 100
¾ "	70 - 85
½ "	65 - 80
3/8"	55 – 75
#4	40 - 65
#16	25 - 40
#200	7 - 11

B. Sand Equivalent (per AASHTO T 176) Not less than 30

C. Fractured Face (per AASHTO TP-61)
Provide at least one mechanically fractured face for a minimum of 50% of particles retained on the #4 US Standard size sieve.

D. Liquid Limit/ Plastic Index (per AASHTO T 89, T 90) Non-plastic

2.1.58 Execution

Road Finish Rock material shall be placed on areas designated on the drawings for roadways or parking. Prior to placing road finish rock the subgrade shall be smoothed and compacted to required specification.

Road finish rock shall be placed in uniform layers not to exceed nine inches (9") in loose thickness, for the entire width of the road surface. Each layer of road finish rock shall be completed, leveled and uniformly compacted before the succeeding layer is placed. Water shall be added or removed, as necessary, in order to obtain the required density. Each lift shall be conditioned to near optimum moisture content and compacted to a density equivalent to at least ninety-five (95%) of the maximum dry density according to ASTM D 1557 or a minimum of ninety-eight (98%) of the maximum dry density according to ASTM D 698, or as recommended in the Geotechnical Report. In place field density shall be measured in accordance with ASTM D 1556 or ASTM D 6938.

14. SECTION 2180 DRAIN ROCK

2.1.59 General

2.1.60 Scope

The work covered by this specification includes the furnishing of all labor, equipment and materials required for placement of Drain Rock as shown on the drawings and as specified herein.

2.1.61 Codes and Standards

Comply with the provisions of the following codes, specifications and standards, except as otherwise shown or specified. The latest edition of the code or standard shall govern.

AASHTO T 27 Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates

2.1.62 SUBMITTALS

A. Contractor shall submit gradation (AASHTO T 27) tests to Owner for review and approval prior to placing any material.

2.1.63 MATERIALS

Drain Rock used for backfilling of oil containment pits or yard drain systems as shown on the drawings shall be sound, hard, durable, clean angular rock. The rock shall meet the following criteria:

A. Gradation (per AASHTO T 27)

Sieve Size	Percent Passing
2"	100
1 1/2"	90 - 100
1"	20 - 55
3/4"	0 - 15

Drain rock shall meet the void ratio requirements specified in the drawings.

B. Rock Quality
Fractured Faces: At least one mechanically fractured face on 95% of all particles retained on each sieve. In addition, at least three mechanically fractured faces on 70% of the same particles.

C. Rock Resistivity
A minimum wet resistivity of 3,000 ohm-m is required for all aggregate surfacing.

2.1.64 EXECUTION

Drain Rock shall be placed in a careful manner to prevent damage to drain piping or liner materials. Drain Rock shall be installed to the elevations or grades as shown on the drawings.

15. SECTION 2190 GEOTEXTILES

2.1.65 GENERAL

2.1.66 SCOPE

The work covered by this specification includes furnishing of all labor, equipment and materials required for placement of geotextile as shown on the drawings and specified herein.

2.1.67 CODES AND STANDARDS

Comply with the provisions of the following codes, specifications and standards, except as otherwise shown or specified. The latest edition of the code or standard shall govern.

AASHTO M 288	Geotextile Specification for Highway Applications

2.1.68 SUBMITTALS

A. Prior to use: Contractor shall submit manufacturers certificate that each fabric complies with requirements of this section and drawings.

2.1.69 MATERIALS

Silt Fence Geotextile - Silt Fence Fabric: See AASHTO M 288 (Table 6 – Temporary Silt Fence Property Requirements)

Drainage Geotextile – Furnish non-woven drainage geotextile as specified in AASHTO M 288 with in-situ soil designations as shown on the drawings or as specified by the Owner. Notify Owner if soil conditions are different than shown on the drawings.

Non-woven geotextile shall be composed of a polypropylene, staple fiber, needle punched, oriented into a stable network which will retain its relative structure during handling, placement and service. The geotextile shall be free of treatments or coatings that will significantly reduce permeability and be resistant to environmental conditions expected at the site.

Minimum non-woven geotextile properties are as follows: Grab tensile strength ASTM D 4632 120 lb.

Grab elongation ASTM D 4632	50%
Mullen Burst ASTM D 3786 Mod.	230 psi
Puncture strength ASTM D 4833	50 lb.
Apparent opening size ASTM D 4751	≤ # 70 sieve
Permittivity ASTM D 4491	1.50 sec^{-1}
Ultraviolet stability ASTM D 4355	70 % strength retained

Erosion Control Geotextile – Furnish non-woven drainage geotextile as specified in AASHTO M 288 with in-situ soil designations as shown on the drawings or as specified by the Owner. Notify Owner if soil conditions are different than shown on the drawings.

Non-woven geotextile shall be composed of a polypropylene, staple fiber, needle punched, oriented into a stable network which will retain its relative structure during handling, placement and service. The geotextile shall be free of treatments or coatings that will significantly reduce permeability and be resistant to environmental conditions expected at the site.

Minimum non-woven geotextile properties are as follows: Grab tensile

strength ASTM D 4632	205 lb.
Grab elongation ASTM D 4632	50%
Mullen Burst ASTM D 3786 Mod.	350 psi
Trapezoidal Tear ASTM D 4533	85 lb
Puncture strength ASTM D 4833	110 lb Apparent opening
size ASTM D 4751	≤ # 80 sieve Water flow
rate ASTM D 4491	110 gpm/ ft^2
Ultraviolet stability ASTM D 4355	70 % strength retained

Separation Geotextile - Furnish Class I fabric as specified in AASHTO M288 with Apparent Opening Size of 0.22 mm maximum average roll value.

Non-woven geotextile - Non woven geotextile shall meet the minimum requirements as per Drainage Geotextile.

Woven geotextile is a slit film. The geotextile shall be free of treatments or coatings that will significantly reduce permeability and be resistant to environmental conditions expected at the site.

Minimum woven geotextile properties are as follows: Grab tensile strength

ASTM D 4632	315 lb.
Grab elongation ASTM D 4632	15%
Mullen Burst ASTM D 3786 Mod.	675 psi
Puncture strength ASTM D 4833	150 lb
Trapezoidal Tear ASTM D 4533	120 lb Apparent
opening size ASTM D 4751	≤ # 40 sieve Water Flow
Rate ASTM D 4491	4 gpm/ft^2
Ultraviolet resistance ASTM D 4355	70 % strength retained

Stability Geotextile and Geogrid – Furnish Class II fabric as specified in AASHTO M288 with Apparent Opening Size of 0.22 mm maximum average roll value.

Woven Geotextile – Woven geotextile shall meet the minimum requirements as per Separation Geotextile.

Geogrid is an integrally formed biaxial geogrid. This is a polypropylene, positive mechanical interlock system suitable for base reinforcement and subgrade improvement.

Minimum Biaxial Geogrid properties are as follows:

Aperture Dimensions 1 inch

Minimum Rib Thickness 0.05 inch Tensile strength @ 2% strain ASTM D 6637 410 lb.

Tensile strength @ 5% strain ASTM D 6637 810 lb. Ultimate Tensile Strength ASTM D 6637 1310 lb Junction Efficiency GRI-GG2-05 93%

Flexural Stiffness ASTM D 5732 750,000 mg-cm

Aperture Stability 0.65 m-N/deg
Resistance to Installation Damage ASTM D 6637

%SC/%SW/%GP 90/90/90

Ultraviolet resistance ASTM D 4355 100 % strength retained

Weed Barrier Geotextile – Furnish fabric as specified in AASHTO M288 with elongation less than 50 percent.

Woven to Non-woven geotextile shall be composed of a polypropylene, staple fiber, needle punched, oriented into a stable network which will retain its relative structure during handling, placement and service. The geotextile shall be free of treatments or coatings that will significantly reduce permeability and be resistant to environmental conditions expected at the site.

Minimum woven to non-woven mix geotextile properties are as follows:

Weight (Oz/Sq Yd) 5.0 oz/sq avg.

Grab tensile strength ASTM D 4632 100 lb.

Grab elongation ASTM D 4632 50%

Mullen Burst ASTM D 3786 Mod. 210 psi

Puncture strength ASTM D 4833 50 lb.

Trapezoid Tear ASTM D 4533 70 lb

Water permeability ASTM D 4491 12 gal/min/SF Ultraviolet resistance ASTM D 4355 70 % strength retained

Cushion Fabric Geotextile– is a polypropylene, stable fiber, needle punched non-woven geotextile. Fabric shall be installed according to drawings and manufacturers recommendations.

Geotextile cushion fabric shall be used for protection of the impermeable membrane and shall meet as a minimum of the following requirements:

Grab tensile strength ASTM D 4632	380 lb.
Grab elongation ASTM D 4632	50%
Mullen Burst ASTM D 3786 Mod.	750 psi
Puncture strength ASTM D 4833	240 lb.
Apparent opening size ASTM D 4751	≤100 US Std Sieve
Permittivity ASTM D 4491	0.7 sec^{-1}
Ultraviolet stability ASTM D 4355	70 % strength

The manufacturer of the liner shall approve Geotextile fabric used for underlayment of spray on liner system.

2.1.70 EXECUTION

A General

i Place geotextile on areas that are smooth, and free of projections or depressions.

ii Install geotextile by unrolling fabric across subgrade. Orient the geotextile and install in the direction of traffic, if applicable.

iii Place first lift at a minimum of 6 inches of suitable fill material over geotextile without driving directly on the material. Do not end dump on the geotextile material.

iv Minimize driving and turning on the first lift of soil placed.

B Install Drainage Geotextile

i Excavate trench as specified on the drawings meeting section 02122 Trench Excavation and Backfill.

ii Cut geotextile to width and place in trench. Geotextile should begin from one side of the trench and finish on the opposite side while lining the bottom of the trench.

iii Overlap each sheet over the next sheet by 12 inches for placement in trench.

iv Anchor the geotextile using pins with a minimum of 18 inches in length or boulders at the top of the trench prior to backfill.

v Repair any damaged areas by placing a patch over area and overlapping by at least 3 feet.

C Install Erosion Control Geotextile

i Install as per drawings or as directed by the Owner.

- ii If installing with rip rap at ends of pipe culvert, place geotextile under culvert.
- iii Overlap the geotextile a minimum of 2 feet or as indicated by the manufacturer’s specifications.
- iv Overlap each sheet over the next downhill sheet for placement on slopes.
- v Anchor the geotextile using pins with a minimum of 18 inches in length.
- vi Repair any damaged areas by placing a patch over area and overlapping by at least 3 feet.

D Install Separation Geotextile

- i Install as per drawings or as directed by the Owner.
- ii Overlap the geotextile a minimum of 1 foot at all longitudinal and tranverse joints or as indicated by the manufacturer’s specifications.
- iii Anchor the geotextile using pins with a minimum of 18 inches in length.
- iv Place fill beginning with overlapped sheets to hold the geotextile while the remainder is backfilled.
- v Repair any damaged areas by placing a patch over area and overlapping by at least 3 feet.

E Install Stabilization Geotextile or Geogrid

- i Install as per drawings or as directed by the Owner.
- ii Overlap the geotextile a minimum of 2 feet at all longitudinal and tranverse joints or as indicated by the manufacturer’s specifications.
- iii Anchor the geotextile using pins with a minimum of 18 inches in length.
- iv Place fill beginning with overlapped sheets to hold the geotextile while the remainder is backfilled.
- v Repair any damaged areas by placing a patch over area and overlapping by at least 3 feet.

F Install Weed Barrier Geotextile

- i Place geotextile on areas that are smooth, and free of large stones or undesirable vegetation.
- ii Cut an “X” over each plant and push geotextile under plant base if placing over an existing bed. Roll geotextile over soil and cut an “X” of each plant hole if placing over a new bed. Fold excess geotextile under and cover with soil or specified landscaping materials.
- iii Anchor the geotextile using pins with a minimum of 18 inches in length.
- iv Place a minimum of 4-inches of approved landscaping material on all areas as indicated on the drawings or as directed by the Owner. Do not leave any of the geotextile exposed to direct sunlight.

v Repair any damaged areas by placing a patch over area and overlapping by at least 3 feet.

vi Maintain surfaces and supply additional landscape materials where necessary including areas affected by erosion.

16. SECTION 2200 DRILLED PIERS

2.1.71 GENERAL

2.1.72 SCOPE

The work covered by this specification includes furnishing of all labor, equipment and materials required for installation of drilled concrete piers as indicated on the drawings and specified herein.

2.1.73 CODES AND STANDARDS

Comply with the provisions of the following codes, specifications and standards, except as otherwise shown or specified. The latest edition of the code or standard shall govern.

Federal Highway Administration (FHWA) Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects, Section 565 dated 2003, FP-03

ASTM D6760 Crosshole Sonic Logging (CSL)

FHWA-NHI-10-016, Drilled Shaft Construction LFRD Design Methods

2.1.74 MATERIALS

Concrete and reinforcing steel shall comply with the requirements of section 3000.

Anchor rods shall comply with the requirements of section 5110.

2.1.75 QUALIFICATIONS AND SUBMITTALS

Submit the following for review at least 10 working days before constructing drilled piers. Owner review of the Contractor's personnel qualifications and installation plan does not relieve the Contractor of the responsibility for obtaining the required results in the completed work.

A *Personnel Qualifications*

Construction Personnel. Use a foreman with at least 3 years of experience in the construction of drilled piers. Foreman must remain on- site during all drilled pier installation activities. Upon request provide a resume of job experience, project description, the owning agency's name and current phone number.

Post Construction Testing Personnel. Personnel performing the nondestructive cross-hole sonic logging (CSL) shall have a licensed professional engineer supervising the testing and interpretation of results. The CSL consultant shall be provided by the Contractor. The CSL consultant shall be an independent testing agency with at least three years of experience in CSL testing. The on-site person(s) performing the testing shall have at least 12 months experience in performing CSL testing. Provide a resume of job experience, project description, owning agency's name and current phone number.

Provide experienced labor support as needed to adequately perform the required tests.

2.1.76 SUBMITTALS

Furnish the following in the installation plan:

A. An overall construction plan and the sequence of drilled pier construction.
B. Details of proposed pier drilling methods; methods for removing materials from the piers; procedures for maintaining correct horizontal and vertical alignment of the excavation; and a disposal plan for the excavated material.
C. A description, including capacities, of the proposed equipment to be used including cranes, drills, drilling unit, augers, bailing buckets, and final cleaning equipment.
D. Demonstrate an understanding of the subsurface conditions at the site. Reference the available geotechnical report and/or any other subsurface data provided by the Owner or Contractor.

E. Details of methods to be used to ensure drilled pier hole stability during excavation and concrete placement. Include a review of the chosen method's suitability for the anticipated site and subsurface conditions. If temporary casings are proposed or required, provide casing dimensions and detailed procedures for temporary casing installation and removal.
F. Details of reinforcement placement including bracing, centering centralizers, and lifting and support methods.
G. Details of concrete placement including proposed operations procedures for free fall, tremie, or pumping methods.
H. The method used to form an emergency horizontal construction joint during concrete placement.

3.2 Other Required Submittals

1. Concrete Mix Design
2. Grout Mix Design (for grouting CSL Tubes, when required)
3. Reinforcing Steel Certifications (including mill certifications)
4. Drilled Pier Installation Record
5. Concrete Pour tickets
6. Densified Drilling Fluid (when applicable)

3.3 Drilled Shaft Installation Preconstruction Meeting

A drilled shaft installation preconstruction meeting shall be held at least five (5) working days prior to the Contractor beginning any shaft construction work at the site to discuss investigative boring information, construction procedures, personnel and equipment to be used, and to review proposed shaft installation plan. Those attending shall include:

Representing the Contractor at the meeting will be the superintendent, on site supervisors, foreman and other key personnel identified by the Contractor. If slurry is used to construct the shafts, the slurry manufacturer's representative and a Contractor's employee trained in the use of slurry.

Representing Owner at the meeting will be the Project Civil Engineer, key Owner inspection personnel and other appropriate representatives.

2.1.77 EXECUTION

A Drilling Operations

i Excavate holes according to the installation plan. Report all deviations from the plan to the onsite inspector.

ii When required, casings shall be installed as the drilling proceeds or immediately after the equipment is withdrawn to prevent sloughing and caving of the excavation walls. Casing shall be advanced ahead of the drilling operation in order to maintain a soil plug capable of producing a positive seal at the bottom that prevents piping of water or other material into or out of the hole.

iii Slurry may be used to stabilize the excavation; however a specific plan, including the material to be used, must be submitted for Owner review prior to use. Refer to FHWA Standard Specifications for Construction of Road and Bridges, Section 565 "Drilled Shaft Installation" for all slurry use requirements.

iv Steel casings of ample strength to withstand handling and installation stresses shall be used. Use casing with the outside diameter equal to or greater than the specified diameter of the pier and the inside diameter not exceeding the specified diameter of the pier by more than 6 inches. Casings are to be removed as the concrete is placed. Casing extraction shall not be aided by the use of a vibratory extractor, unless authorized by the Owner. During removal, the casing shall be kept plumb and the concrete head shall be maintained at a level to offset the water head outside the casing. As a minimum, a concrete head of 4 to 5 feet shall be maintained above the bottom of the casing during the casing removal.

v Each drilled pier shall be accurately located, sized and plumbed. The maximum deviation of the drilled pier from its designated location shall not be more than 2 inches at its top elevation. The drilled pier shall not be out of plumb more than 1 inch in 5 feet of height. Deviation of the drilled pier location within the specified limits shall not be cause for deviation in anchor bolt or concrete cap location. Adjustment shall be made for all concrete embedments.

vi Each drilled pier excavation shall be made to the approximate depth indicated on the drawings. All weathered and loose material shall be removed. The Owner shall verify the final tip elevation before concrete placement. The Contractor shall remove excavated materials from the site. Classification of the excavated materials will not be made except for identification purposes. Drilled pier excavation shall include the removal and handling of all excavated materials.

vii Blasting to accommodate drilling operations will not be permitted on the site.

viii All drilled pier excavations will be inspected by the Owner before the placement of concrete. All drilled pier excavations that cannot be visually inspected shall be treated as a wet hole. Refer to wet method for concrete placement.

4.1 Reinforcing Steel and Placement of Crosshole Sonic Logging Access Tubes

A. Reinforcing steel shall conform to Section 3000.2.6.

B. Reinforcing steel shall be tied at all (100%) intersections of vertical and horizontal bars. Individual or loose bars are not permitted.

C. Securely wire together contact reinforcing steel lap splices. Tie and support the reinforcing steel so it remains within the required tolerances. Securely tie concrete spacers or other approved spacing devices at filth points around the cage perimeter and space at internals not to exceed 10 feet along the length of the cage. Use spacers of approved material at least equal in quality and durability to the pier concrete. Acceptable feet made of plastic, or concrete shall be provided to ensure that the bottom of the cage is maintained at the proper distance above the base of the excavation unless the cage is suspended from a fixed base until concrete has set sufficiently to support the weight of the cage at the proper elevation.

D. Place reinforcing steel cage as a unit immediately after the pier excavation is completed and inspected prior to concrete placement. Handle reinforcing cages to avoid distortion or racking of the steel. During concrete placement, provide positive support from the top of the reinforcing steel cage. Maintain the top of the reinforcing steel cage no more than 6 inches above and no more than 3 inches below the required position. All bracing steel used to stabilize the cage during placement shall be removed prior to concrete placement.

E. Provide cross-hole sonic logging access tubes for all drilled piers of 6 feet in diameter or greater and/or 50 feet or greater in length, and all wet method construction. Install (1) access tube for every foot of diameter.

F. Provide cross-hole sonic logging access tubes of standard weight black steel pipe per ASTM A53 with nominal inside diameter of 2 inches. Use pipe and pipe joints that have a round, regular internal diameter, free of defects or obstructions, and will result in watertight access tubes that permit the free, unobstructed passage of source and receiver probes. Use access tubes that are free of corrosion, that have clean internal and external faces to ensure probe passage, and that have a good bond between the concrete and tubes.

G. Fit the access tubes with a water-tight shoe on the bottom and a removable cap on top.

H. Secure tubes firmly to the interior of the reinforcement cage. Install the tubes in a regular, symmetric pattern such that each tube is the maximum possible distance from each adjacent tube. Tubes shall be as near to parallel as possible. The tubes shall be installed from ½ foot above the pier bottom to at least 2 feet above the ground surface. Do not bend or damage the tubes during reinforcement installation operations.

I. Completely fill access tubes with water and maintain water level until Cross-hole sonic logging tests can be performed.

J. Contractor shall provide independent CSL testing agency.

K. Contractor is responsible to fully grout access tubes after Cross-hole sonic logging tests are approved by the Owner. Grout for filling access tubes shall be a cement grout with a maximum water/cement ratio of 0.45.

4.2 Concrete Placement

A. Dry Method

Use the dry construction method at sites where the groundwater level and soil conditions are suitable to permit construction of the pier in relatively dry excavation and where the sides and bottom of the pier may be visually inspected before placing concrete.

i. Unless otherwise accepted by the Owner, concrete shall be placed in drilled pier holes within 24 hours of completing excavation.

ii. All water and loose materials shall be removed from the holes and reinforcement shall be thoroughly cleaned before concrete is placed.

iii. Concrete shall be placed with a tremie or funnel to prevent segregation. Use free-fall placement only in dry holes with a maximum 6-foot free-fall height or Owner approved height. The concrete shall fall directly to the pier base without contacting either the rebar cage or hole sidewall. If concrete placement causes the pier excavation to cave or slough or if the concrete strikes the rebar cage or sidewall, reduce the height of free-fall and reduce the rate of concrete flow into excavation. If placement cannot be satisfactorily accomplished by free-fall, use tremie or pumping to place concrete.

iv. Concrete shall be rodded or vibrated in the top third of the drilled piers to provide a dense mass free of voids. As placed, the concrete shall have a slump between 6 to 8 inches. During the filling of the drill holes, if water begins to accumulate on the top of the concrete, the amount of water in succeeding batches shall be reduced. When scum or laitance accumulates on the top of the concrete, it shall be removed and replaced to the proper elevation.

v. Concrete shall be placed in a continuous process. The quantity of concrete required to fill the drilled hole of the pier shall be available at the site when concrete is placed in each hole. If concrete placement for any pier is suspended for more than 30 minutes, laitance and water shall be removed from the joint surface and the joint surface shall be coated with epoxy bonding compound before placement is resumed. Epoxy bonding compound shall be at the site before the concrete placement is started.

vi. Drilled piers shall be reinforced as indicated on the drawings.

Reinforcement shall be installed and secured to prevent shifting during concrete placement. Each drilled pier shall be cured as specified in the specification 3000.

vii. All casings shall be removed unless approved by the Owner. If approved casings are left in place, the void areas between the form and the excavation walls shall be filled with lean concrete mix. The lean concrete or grout mix shall be placed and tamped to fill the annular space.

viii. Records of the exact volume of each drilled pier excavation shall be kept. This volume shall be compared to the volume of concrete actually placed in each drilled pier. If the concrete volume placed is less than the calculated drilled pier volume, the Owner shall be notified.

ix. Concrete shall maintain a minimum 6-inch and maximum 8-inch slump for the duration of the pour. For all concrete pours with a duration of 6 hours or more the Contractor shall provide a slump loss test with concrete submittal.

B. Wet Method

Use the wet construction method or the casing construction method for piers that do not meet the above requirements for the dry construction method.

i. Concrete shall not be deposited under water except with Owner permission. The proportions for underwater concrete mix shall be adjusted to provide 7 to 9 inches of slump and the cement factor shall be increased by one sack per cubic yard.

ii. Underwater concrete shall be placed through a tremie equipped with a seal at the lower end and a hopper at the upper end. The tremie shall be watertight and large enough to allow a free flow of concrete. After the flow of concrete is started, the lower end of the tremie shall be kept below the surface of the deposited concrete. The entire mass of concrete shall be placed as quickly as possible and shall flow into place without shifting horizontally under the water. Make the tremie inside diameter at least 6 times the maximum aggregate size used in the concrete mix.

iii. The water shall be quiescent when concrete is deposited. After placing, the ground water level in the area adjacent to the drilled pier shall be kept static (no pumping) until the concrete has taken its initial set.

iv. Concrete shall maintain a minimum 7 inch and maximum 9 inch slump for the duration of the pour. For all concrete pours with duration of 6 hours or more the Contractor shall provide a slump loss test with concrete submittal.

v. When the wet method is used the water level shall be maintained to obtain hydrostatic equilibrium throughout the construction operation at a height required to provide and maintain a stable hole, but not less than 5 ft above the water table.

4.3 Drilled Pier Installation Record

An accurate record of the drilled concrete pier installation shall be completed that contains as a minimum the following information for

each. The Contractor shall submit the installation record to the Owner Field Representative at the end of each day. It will not become official until the Owner Field Representative agrees with the accuracy and completeness and approves the document.

The drilled pier installation record shall contain the following information:

- Contractor's name
- Drilled Pier number and location
- Depth to bedrock
- Depth to water
- Final depth if different from design drawings
- Note any caving, sloughing of excavation and drilling difficulties
- Casing insertion, size and length, and whether or not removed
- Date and time of start and finish excavation
- Length and diameter of reinforcing bar cage if different from design drawings
- Date and time concrete placed
- Calculated volume of excavation based on diameter of pier
- Total quantity of concrete placed
- Concrete Yield Plot
- Concrete batch plant ticket numbers
- Concrete slump, temperature, air content, strength

4.4 Timing of the Cross-hole Sonic Logging (CSL)
The drilled shaft shall be tested no sooner than three (3) calendar days after placement of concrete but within 45 days after placement.

After all CSL testing has been completed, and after acceptance of the drilled shaft test results by the Owner, the Contractor shall remove the water in the tubes, place grout tubes extending to the bottom of the access tube and fill all access tubes in the drilled shaft with grout. Cut CSL tubes at surface as indicated on drawings or flush with top of concrete.

17. SECTION 2210 ASPHALTIC CONCRETE PAVING

2.1.78 GENERAL

2.1.79 SCOPE

The work covered by this specification includes furnishing of labor, equipment and materials required for preparing the sub-base, subgrade, and placing of hot mix asphalt pavement as shown on the drawings and as specified herein.

2.1.80 CODES AND STANDARDS

Comply with the provisions of the following codes, specifications and standards, except as otherwise shown or specified. The latest edition of the code or standard shall govern.

ASTM D2041	Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures (Rice)
ASTM D 946	Penetration-Graded Asphalt Cement for Use in Pavement Construction
ASTM D 1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN- m/m^3))
ASTM D 1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 6938	Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
AASHTO T 19	Unit Weights and Voids in Aggregate
TAI MS-2	Mix Design Methods for Asphalt Concrete and Other Hot Mix Types
TAI MS-3	Asphalt Plant Manual
TAI MS-8	Asphalt Paving Manual
TAI MS-19	Basic Asphalt

2.1.81 SUBMITTALS

A. Submit mix design at least 10 working days before paving. Do not pave until Owner has approved the mix design.

B. Submit Road Finish Rock to be used as sub grade material according to Section 2170 Aggregate Surfacing – Road Finish Rock.

C. Submit new mix design if materials used change during construction. Provide written documentation explaining the reason for the change in material.

2.1.82 MATERIALS

All materials shall be in accordance with the above referenced specifications. Aggregate and asphalt mix design shall be submitted for review prior to construction.

2.1.83 EXECUTION

A Sub-base

Contractor shall grade and compact the sub-base layer prior to placing road finish rock (untreated base course) as recommended in the Geotechnical Report or as directed by the Owner. Owner shall inspect sub-base layer prior to placing road finish rock.

B Sub Grade

Contractor shall place road finish rock according to section 2120 Site Grading. Road finish rock shall meet specification Section 2170 Aggregate Surfacing – Road Finish Rock and drawings.

C Surface Preparation

i Locate, reference, and protect all utility covers, monuments, curb and gutter and other components affected by the paving operations.

ii Remove all moisture, dirt, sand, leaves, and other objectionable material from the prepared surface before placing mix.

iii Do not place HMA on frozen base or during adverse climatic conditions such as precipitation or when roadway surface is icy or wet.

D 3.4 Primer

Contractor shall apply primer in accordance with manufacturer instructions on aggregate and all contact surfaces. Excess primer shall be blotted with clean sand.

E Tack Coat

Contractor shall apply a tack coat in accordance with manufacturer instructions and TAI MS-19. Apply tack coat on all contact surfaces to a minimum rate of 1/3 gallon per square yard. Allow sufficient cure time for prime coat/tack coat before placing hot mix asphalt.

F Placing Single Course Asphalt Pavement

Contractor shall place a minimum of three inches of asphalt within 24 hours of applying primer and tack coats. Compact pavement with rolling equipment or in tight areas with hand operated compactors. Perform rolling to with consecutive passes to achieve even and smooth surface without voids or roller and compactor marks. Compaction requirements see section 3.7.

G Tolerances

Final surface shall be within ¼ inch in 10 feet and allow surface water to freely drain the finished surface.

H Protection

i Contractor shall immediately after placement, protect pavement from mechanical injury for 24 hours or until surface temperature is less than 140 ºF.

ii Do not allow construction vehicles, general traffic, or rollers to pass over the uncompacted end or edge of freshly placed mix until mat temperature drops to a point where damage or differential compaction will not occur.

iii Taper the end of a course subjected to traffic at approximately 50:1 (horizontal to vertical).

(a) Remove the portion of the pass that contains the tapered end before placing fresh mix.

(b) Tack the contact surfaces before fresh mix is placed against the compacted mix.

iv Use a motor grader, spreader box, or other approved spreading methods for projects under 180 square yards, irregular areas, or for miscellaneous construction such as detours, sidewalks, and leveling courses.

I Compaction and Density

i Use a small compactor or vibratory roller at structures in addition to normal rolling.

ii Create a rolling pattern to drive approaches and aprons to aid in compaction. Rolling patterns should be approved by Owner before being driven.

iii Owner will provide a testing agency to verify compaction efforts according to ASTM D6938. A field sample of HMA shall be taken every 200 feet or once daily for small projects, whichever is of a higher frequency. Laboratory tests shall include ASTM D 2041 (Rice). Contractor shall reach a minimum average target for in-place density of 95% of the theoretical maximum specific gravity and density of bituminous paving mixtures (Rice). No test shall be less than 92%.

iv Asphalt which does not meet these requirements or is suspect shall be verified at the Contractor’s expense by providing a minimum of one core every 100 feet.

v Contractor obtains cores within two days after the pavement is placed.

(a) Coring locations shall be marked by Owner for in-place density verification.

(b) Move transversely to a point 2 feet from the edge of the pavement for in-place density if random location for coring falls within 2 feet of the edge overall pavement section (shoulders).

(c) Fill core holes with HMA or high AC content cold mix and compact.

(d) Owner approved testing agency witnesses the coring operation, takes possession of the cores immediately, and begins testing the cores within 24 hours of density acceptance.

18. SECTION 2220 CULVERTS

2.1.84 GENERAL

2.1.85 SCOPE

The work covered by this specification includes furnishing of labor, equipment and materials required for installation of corrugated steel, concrete and plastic pipe culvert, joints, accessories, bedding and slope protection at pipe end.

1.2 References

AASHTOT 180	Moisture-Density Relations of Soils Using a 10-lb. (4.54-kg) Rammer and an 18-in. (457-mm) Drop
ASTM A 760	Standard Specification for Corrugated Steel Pipe, Metallic- Coated for Sewer and Drains
ASTM C 14	Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe
ASTM C 76	Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C 443	Standard Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets
ASTM D 698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 lbf/ft3 (600 kN-m/m3))
ASTM D 1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3))
ASTM D 1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 6938	Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

2.1.86 SUBMITTALS

Contractor shall submit manufactures product data and installation instructions on pipe, fittings and accessories. Any special procedures required to install specified products shall be noted. Submittals shall be received at least two weeks before start of work.

Contractor shall provide submittals as required by Section 02122 Trench Excavation and Backfill.

2.1.87 PRE-INSTALLATION CONFERENCE

Contractor shall convene a Pre-Installation Conference one week before commencing work of this Section, if required under provisions of local, state or federal highway encroachment permits.

2.1.88 Regulatory Requirements

Conform to applicable highway specifications and codes for materials and installation of the work of this section within local, state and federal highway right- of-way.

2.1.89 Materials

A Culvert Pipe

i Corrugated Steel Pipe:

(a) ASTM A 760 II zinc metallic coated.

(b) Shape: Circular or elliptical with nominal dimensions as shown on the drawings.

(c) Tapered Ends: Same material as pipe, machine cut, for joining to pipe end.

(d) Coupling Bands: Galvanized steel, 0.052 inches thick x 10 inches wide; connected with two neoprene "O" ring gaskets and two galvanized steel bolts.

B Concrete Pipe:

i ASTM C 14, Class 3; un-reinforced; plain end joints:

ii Shape: Circular with a nominal diameter as shown on the drawings.

iii Concrete Pipe Joint Devices: ASTM C 443, rubber compression gasket joint.

C Reinforced Concrete Pipe

i ASTM C 76, Class IV with Wall Type B bar reinforcement; bell and spigot end joints:

ii Shape: Circular with a nominal diameter as shown on the drawings.

iii Reinforced Concrete Pipe Joint Device: ASTM C 443, rubber compression gasket joint.

D Bedding and Backfill Materials

Bedding and backfill material shall be crushed aggregate surfacing as defined in Section 2170 Road Finish Rock.

E Accessories

i Filter Fabric: not required.

ii Materials at Pipe Ends: As required by permitting agency. Alternatives are soil cement material blend with 6 percent cement, premixed and burlap bagged for moist cure on site; rip rap rock with a nominal size of 12 inches.

iii End of Culvert Gratings: not required.

2.1.90 EXECUTION

A Trench Excavation

- i Excavate culvert trench to 6 inches below pipe invert and to the depth and width shown on the drawings. If excavating through soft silty clay soils, use a smooth edge bucket to avoid disturbance of the bottom of the trench.
- ii Cut trenches sufficiently wide to enable installation of culvert and allow room for compaction of backfill around the pipe and inspection.
- iii Excavations shall not interfere with the bearing splay of foundations, about 45o from the foundation base.
- iv Excavate by hand for accurate placement of pipe to elevations indicated.
- v Remove loose, lumped or frozen subsoil, boulders, rock greater than two (2") inches in diameter and other deleterious matter which could damage piping or impede consistent backfilling or compaction.
- vi Correct areas over excavated by backfilling with bedding material as defined below.
- vii Stockpile excavated material, if suitable for backfilling, in area designated within the construction limits and remove excess material not being used, from the site.

B Examination

Before installation of culvert pipe, verify that trench base and excavations are true to the dimensions and elevations that are as indicated on the layout drawings.

C Bedding

Place bedding material at trench bottom and level bedding materials in one continuous layer not exceeding 6 inches in compacted depth. Compact to 92 percent of maximum dry density as determined by ASTM D 1557.

Backfill around sides to the top of the pipe. Tamp and compact each lift a minimum of (92%) ninety-two percent of the maximum dry density as determined by ASTM D 1557. Do not displace or damage pipe when placing or compacting backfill.

Maintain +/- 2% of optimum moisture content of the bedding material to attain the required soil density.

D Installation - Pipe

Install pipe and accessories in accordance with manufacturer's instructions. Lift or roll pipe into

position. Do not drop or drag pipe over prepared bedding.

Protect pipe and bedding from damage or displacement until backfilling operation is in progress.

Lay pipe to slope gradients noted on layout drawings with maximum variation from true slope of 1/8 inch in 10 feet.

Shore pipe to required position to ensure pipe remains in correct alignment and at the required slope until after compaction of adjacent fills is completed.

Repair surface damage to pipe protective coating with two coats of compatible bituminous paint coating.

E Materials at Pipe Ends

Place materials at pipe ends as defined in section 2.3A, at embankment slopes and as indicated on the drawings, to the subscribed average thickness.

F Laying Tolerances

Culvert invert elevation: ½" Alignment offset: 1"

Profile: 1%

G Field Quality Control

All field-testing and inspection shall be performed by an independent testing agency hired by the Owner.

Inspection and testing will be performed before and immediately after placing aggregate cover over pipe. Inspection shall include checking for compliance with erection tolerances and placement specifications. Testing shall check compliance with bedding and backfill materials, and compaction. Tests shall be performed in accordance with ASTM D 1557, D 698 and D 6938.

If inspections and tests indicate work does not meet specified requirements, the work shall be removed, replaced, inspected and tested.

Test and inspections shall be performed for each culvert at road crossings or every 50 linear feet of culvert.

19. SECTION 2230 SEEDING AND EROSION CONTROL

2.1.91 General

2.1.92 Scope

The work covered by this specification includes furnishing of all labor, equipment and materials required by the Erosion and Sediment Control Plan (ESCP). Excluded are areas within the substation fence.

2.1.93 Materials

Materials shall meet the following requirements:

Matting: Matting shall be biodegradable as the grasses become established.

Fertilizers: Standard commercial manufacture.

Mulch: Provide mulch materials free of noxious weed seeds and plants. Mulch shall be processed to have the ability to cover and hold grass seed in contact with the soil.

Seed: Supplied by a state certified seed vendor. Seed mixture shall include a variety of grasses, all of which are suitable to the local climate.

2.1.94 EXECUTION

Contractor shall perform this work when local weather conditions are favorable. Contractor shall adhere to the post construction and soil stabilization Best Management Practices (BMP's) as indicated in the ESCP.

Remove all rocks, weeds, debris and matter detrimental to seed germination and growth. Cultivate surface soil to a condition favorable to seed growth.

Form minor ridges in the fill and cut slopes to retard erosion and improve germination.

Apply seed and fertilizer as recommended by the seed supplier. Contractor shall use hydroseeding techniques to apply seed and mulch.

In ditches and where running water is possible Contractor shall apply matting. Matting shall be placed in strips in the direction of water flow. Place matting in contact with the ground at all points and secure in place with wire staples.

2.1.95 SECTION 2240 SOIL STERILIZATION

2.1.96 GENERAL

2.1.97 SCOPE

The work covered by this specification includes furnishing of all labor, equipment and materials required for application of soil sterilant as shown on the drawings and specified herein.

2.1.98 SUBMITTALS

Contractor shall submit the following for Owner records:

A. Copy of applicators license (if required by state regulations or Department of Environmental Quality (DEQ))
B. Material Safety Data Sheets (MSDS) for selected herbicide.

2.1.99 MATERIALS

Contractor shall be responsible for selecting herbicide(s) which are most effective for the given season of application, soil conditions and plant material at the substation site and which minimize the potential for environmental impact to surrounding areas. Herbicide(s) shall be selected and applied in a manner to prevent plant growth for a minimum period of one year from date of application. Extra precaution in herbicide selection is necessary if the substation site is accessible to wetlands or waterways. Only herbicide(s) with current EPA registration shall be used.

2.1.100 EXECUTION

Contractor shall obtain a certified applicator's license if restricted use herbicides are applied. Contractor shall also obtain all necessary state licenses for application of selected herbicide(s). Herbicide(s) shall be applied in strict accordance with manufacturer's instructions and in a manner to avoid migration outside treated areas.

Unless otherwise indicated or shown on the drawings, Contractor shall apply herbicide(s) over all areas within the substation and five (5) feet outside the substation fence.

Storage and disposal of herbicide(s) is the responsibility of the Contractor. Contractor shall follow manufacturer's instructions for herbicide storage and disposal. Contractor shall be responsible for proper handling and disposition of any unused herbicide(s).

3 Concrete

20. SECTION 3000 REINFORCED CONCRETE

3.1.1 GENERAL

3.1.2 SCOPE

Furnish all material, equipment, accessories, tools, services, transportation, labor, and supervision required for the supply and installation and testing of cast in place concrete. The index to this specification is as follows:

3.1.3 CODES AND STANDARDS

Comply with the provisions of the following codes, specifications and standards, except as otherwise shown or specified. The latest edition of the code or standard shall govern.

ACI 211 Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete.

ACI 212 Chemical Admixtures for Concrete

ACI 301 Specifications for Structural Concrete for Buildings

ACI 304 Guide for Measuring, Mixing, Transporting and Placing Concrete ACI 305R Hot Weather Concreting

ACI 306R Cold Weather Concreting

ACI 315 Details and Detailing of Concrete Reinforcement ACI 318 Building Code Requirements for Structural Concrete ACI 347Guide to Formwork for Concrete

American Welding Society D12.1, Recommended Practices for Welding

Reinforcing Steel, Metal Inserts, and Connections in Reinforced Concrete Construction

Concrete Reinforcing Steel Institute (CRSI), as noted.

3.1.4 MATERIALS

A Cement shall be Portland Cement conforming to ASTM C 150, Type II, or as specified by Geotechnical Engineer. All cement supplied shall be of one manufacturer.

B Water used in mixing shall be clean and free from deleterious amounts of acids, alkalis, organic matter, or other impurities likely to be injurious to concrete.

C Admixtures:

i Chemical Admixtures shall conform to "Chemical Admixtures for Concrete" (ASTM C 494) and shall not be used unless prior approval in writing is obtained from the Owner. Where approved, the admixture shall maintain or improve the strength of concrete of the original design mix. Admixtures shall be used in strict accordance with the manufacturer's recommendations and shall be accompanied by the services of the qualified field representative of the manufacturer to supervise the use thereof. A certificate from an approved laboratory attesting that the admixture equals or exceeds ASTM C 494, Type D will be required.

ii Air Entraining Admixtures shall conform to "Specifications for air-Entraining Admixtures for Concrete" (ASTM C 260). Air content shall be determined in accordance with ASTM C 231. The agent and the cement proposed for use shall be selected well in advance of concrete placing. Approved air-entraining admixtures are as follows:

Darex AEA (Grace Construction Materials) MB-VR (Master Builders Company) Sika AER (Sika Chemical Corporation)

iii The use of accelerators shall not be allowed unless approved by the Owner.

D Aggregate:

i Fine aggregate shall conform to "Concrete Aggregates" (ASTM C 33), except for gradation which shall be as follows:

Sieve Size	Percent Passing by Weight
3/8 inch	100
No. 4	95-100
No. 16	45-80
No. 50	7-30

No. 100	No More Than

ii Coarse aggregate shall conform to "Concrete Aggregates" (ASTM C 33), except for gradation which shall be as follows:

Sieve Size	Percent Passing by Weight
1 inch	100
3/4 inch	90-100
3/8 inch	20-55
No. 4	0-10

E Concrete Quality:

i All concrete shall meet the quality requirements specified in ACI 318, Chapter 4.

ii The 28-day compressive strength, fc', of the concrete shall not be less than 4000 psi or as specified on the drawings.

iii Method of proportioning shall be in accordance with ACI 211.1, "Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete."

iv The determination of the water-cement ratio to attain the required strength shall be in accordance with ACI 301, Method 2 (For combinations of materials previously evaluated or to be established by trial mixes), and with ACI 211.1. In addition, the maximum water- cement ratio (by weight) shall be 0.45 and the minimum cement content shall be six (6) sacks per cubic yard.

v From the test results of the aforementioned procedures, a curve shall be plotted showing relationship between the water-cement ratio and compressive strength, and the maximum water-cement content ratio to be used shall be the value shown by the curve to produce the strength a minimum of 25 percent greater than the strength specified.

vi The concrete mix design shall be submitted to the Owner for approval at least two weeks prior to beginning of any concrete work.

vii Maximum aggregate size shall meet the requirements of ACI 318, Section 3.3.

viii Unless otherwise noted or approved, all concrete shall be air-entrained. Air entertainment shall be accomplished using an approved admixture.

ix Air Content shall be 3.5 to 6.5 percent.

x Slump shall be between two (2) and four (4) inches, except for drilled piers. See specification 02200 for drilled pier concrete slump requirements.

xi Mixing, transporting and placing concrete shall conform to applicable portions of ACI 211, ACI 212 and ACI 304 and as specified herein.

F *Reinforcement:*

i Deformed reinforcing steel bars shall conform to ASTM A 615, Grade 60 unless noted otherwise. Bars shall be tagged with marked number and size before shipment. Welding of ASTM A615 bars is not permitted. Where welding of deformed bars is required, such bars shall conform to ASTM A 706.

ii Coated Bars: if specified by the drawings, reinforcing bars shall be either galvanized or epoxy coated. Galvanized-coated reinforcement shall be Class I hot dipped after fabrication zinc coated in accordance with ASTM A 767. If the galvanized surface is damaged prior to placement of concrete, it shall be repaired in accordance with ASTM A 780. Epoxy coated reinforcement shall be epoxy coated in accordance with ASTM A 775. If the epoxy surface is damaged prior to placement of concrete, it shall be repaired with 3M Scottcoat 306 in accordance with manufacturer's specifications.

iii Welded Wire Fabric shall conform to "Welded Steel Wire Fabric for Concrete Reinforcement" ASTM A 185.

iv All cold-drawn steel wire for concrete reinforcement shall be in accordance with ASTM A 82.

v Synthetic reinforcing fibers shall be collated fibrillated polypropylene, as manufactured by Fibermesh, Inc. or equal.

vi Accessories shall conform to CRSI Manual of Standard Practice of Reinforced Concrete Construction. Include all devices necessary for proper placing, spacing, supporting, and fastening steel reinforcement in place. Accessories shall be galvanized after fabrication if underside of concrete will be exposed.

vii Concrete squares, or dobies, shall be approximately two inches square and of a thickness adequate to provide the cover for the reinforcing steel as called for on the plans. The squares shall be made using a mixture of one part Portland Cement to three parts sand (fine aggregate) and the tie wires shall be cast integrally with each square.

G *Formwork:*

i Formwork shall be designed for loads and lateral pressures outlined in Chapter 1, Guide to Formwork for Concrete (ACI 347) and wind loads as specified by the controlling local building code. Formwork design and construction are the responsibility of the Contractor.

ii Forms shall be constructed of wood, steel, or other approved material. Material shall be chosen based on strength and concrete finish requirements.

H Embedded Items:

i Anchor rods shall comply with section 05110.

ii Embedded metals shall comply with section 05100.

iii Waterstops shall be of the dumbbell or center built type made from either rubber, PVC or TPER unless otherwise noted on the drawings. The Owner representative before installation shall approve type and material of water stop.

iv Expansion joint filler shall be ½" thick and shall meet the requirements of ASTM D 1751 for bituminous type or ASTM D 1752 or ASTM D 2628 for non-bituminous type. Where required or shown on the drawings a non-impregnated compressible foam backer rod shall be installed in the expansion joint prior to applying joint sealer. The backer rod shall be 1/8" inch larger in diameter than the joint width and shall be placed in the joint to provide a clear depth above the backer rod from the finished concrete surface equal to one half the joint's width.

v Joint sealer shall conform to ASTM D 1190. Sealant used in expansion joints requiring backer rods shall be a non-priming urethane sealant conforming to ASTM C 920.

vi Subsurface covering shall be polyethylene sheeting 6 mil (0.006") thick natural clear conforming to ASTM D 2103.

vii Felt joints shall be 15-lb. asphalt felt shall conform to ASTM D 250.

3.1.5 EXECUTION

A Preparation:

i In no case shall concrete be placed on muddy, spongy, or frozen subgrade.

ii All wood scraps and debris shall be removed from the areas in which concrete is to be placed.

iii All areas where concrete is to be placed shall be thoroughly cleaned to ensure proper placement and bonding.

iv Forms and subgrade shall be wetted and all standing water removed prior to placing concrete.

v All transporting and handling equipment shall be thoroughly cleaned.

B Form-work:

i Installation: Forms shall be constructed to the shape, line, and grade required and shall be maintained sufficiently rigid to prevent deformation under load, including placing and compacting of concrete. Set forms and screens for floor and decks to provide uniform slopes to drains and positive drainage for exterior slabs and steps. Forms shall be tight enough to prevent leakage of mortar. Formwork shall be secured to prevent sagging, yielding, bulging, depressions, waves, or other defects in the finished work. Forms shall be smooth and free from warp. Temporary openings shall be provided at base of column and wall forms for cleaning and inspection. All debris including mud shall be removed before placing concrete. Use of patented prefabricated panel sections for forming straight wall sections shall receive prior approval of type and procedure including type of ties to be used. Lumber once used shall be carefully cleaned and oiled before reuse.

ii Earth Sides: Earth sides shall not be used except for drilled piers where the top is formed to at least six inches below finished grade.

iii Chamfering: Exposed corners of concrete shall have ¾" chamfers or tooled edges unless shown otherwise.

iv Form Treatment:

(a) Board Forms: Keep wet previous to placing concrete; wet thoroughly just before placing.

(b) Plywood Forms: For surfaces to be painted use silicone type bondbreaker, Burke, West Chemical or approved equal, applied in accordance with manufacturer's directions. Coat other surfaces with approved stainless form oil, using minimum quantity required for satisfactory removal.

(c) Metal Forms: Approved type release compound, applied in accordance with manufacturer's directions.

v Form Removal: Side forms of walls and beams can be removed after 1 to 3 days. Load-supporting forms and shoring shall not be removed until after 7 days or two-thirds of designed 28 day compressive strength is obtained or the 7-day test cylinders have been tested and results indicate an average strength adequate to support the load imposed on the concrete. All forms shall be completely removed after setting of concrete together with all temporary supports, etc., employed for construction purposes. Forms shall be readily removable without hammering or prying against the concrete. Days having temperatures below 40oF are not to be counted for form removal unless thermal protection for the concrete has been provided.

C Reinforcement:

i Detailing and Fabrication:

(a) Reinforcing steel shall be detailed and fabricated in accordance with ACI 315.

(b) The fabricating Contractor shall prepare complete placing drawings and bending schedules. All shop drawings shall be submitted to the

Owner Representative for review. No fabrication or reinforcing steel shall be done until drawings have been reviewed.

ii Splicing:

(a) Notwithstanding the immediately following sentence, no splices shall be made within the Project Substation, including both power and instrument and control conductors. Shields may be spliced where necessary to permit connection to the Project Substation ground system.

(b) Bar splices shall be made in accordance with ACI 318 Chapter 12 unless noted otherwise on the design drawings. Any deviation will require approval of the Owner representative.

(c) When welded splices are specified on the design drawings, the welding shall conform to AWS D 12.1.

(d) Splices in welded wire fabric shall be made by lapping a minimum of one spacing of outermost cross wires of each fabric sheet plus two inches.

D Installation: Before being placed, reinforcing shall be free from loose flaky rust, oil, grease, mud, or other coating, including ice that would reduce or destroy the bond. Reinforcement shall be accurately placed and properly secured in position by pre-cast concrete squares, metal chairs or spacers. The use of heat to bend or straighten reinforcing will not be permitted. Tolerances, spacing, splices, and concrete protection shall conform to Chapter 7 and 12 of the ACI 318 Building Code.

E Ties: With the exception of temperature reinforcement, which shall be tied to main steel, reinforcement shall be accurately placed and securely tied at all intersections and splices with 18 gauge black annealed wire, and shall be securely held in position during the placing of concrete by spacers, chairs, squares, or other approved supports. Wire tie ends shall point away from the form. Unless otherwise indicated, the number, type, and spacing of supports shall conform to ACI 315 Manual.

F Stirrups: All stirrups, except ties, shall be held in place by two spacer bars extending the full length of the beam or girder.

G Mesh: Reinforcing mesh shall be installed by one of the following methods to obtain the spacing indicated on the drawings:

i Deposit a layer of concrete and strike off at the level required for the indicated spacing. Lay the mesh on the struck-off surface, place reinforcing bars, if required, and then continue pouring to full slab thickness. Use this method only when position of mesh is critical.

ii Place mesh on pre-formed concrete blocks wired to the mesh, pour concrete, and adjust mesh as required. This is the preferred method when exact positioning is not critical.

H *Watertight Construction: Standard accessory items (i.e. chairs, etc.) shall not be used in the construction of tanks, reservoirs, basins or other structures to contain water or sewage. All reinforcing steel in the walls, beams, columns and slabs of such structures shall be supported on and held away from the forms by using pre-cast concrete "squares" so that no metal is exposed on the face of the concrete when the forms are stripped.*

I *Synthetic Fiber Secondary Reinforcement: When indicated on the drawings, synthetic fiber secondary reinforcement shall be added to concrete mix to provide concrete crack control. Method of fiber addition to concrete, amount of fibers added, and mixing time shall be in accordance with manufacturer's recommendations.*

J *Embedded Items:*

i No pours are to be made until all embedded items, anchor rods, electrical conduits, steel frames, pipe supports, etc., are properly positioned and secured. The Contractor shall be responsible for and coordinated with other trades to obtain necessary data and information.

ii All sleeves, inserts, anchor rods, waterstops, and other embedded items shall be positioned accurately and supported against displacement.

iii Anchor Rods:

(a) Fabrication: Anchor rods shall be fabricated in accordance with specification 05110.

(b) Installation: Anchor rods shall be set true to the lines and grades shown on the drawings and shall be set plumb and be securely braced to prevent displacement during placing of concrete. Exposed threads shall be protected by coating with oil or grease and encasing them in burlap or paper. Upon completion of concrete placement, anchor rods shall be rechecked for correct location and elevations. When any anchor rod exceeds acceptable tolerances such corrections as are necessary shall be made at no additional cost to the Owner.

(c) Anchor Tolerances: Tolerance limits in setting of anchor rods shall be as follows:

Location, sleeved:	3/16 inch Location, unsleeved: 1/8 inch
Projection:	plus 1/4 inch, minus 0 inch

iv Embedded Metals:

v Fabrication: embedded metals shall be fabricated in accordance with specification 5100.

vi Installation: All embedded curb angles, beams, frames, pipe sleeves, etc. shall be set true to the lines and grades shown on the drawings.

Embedded items shall be secured and braced to prevent shifting during concrete placing. Where dissimilar metals are to be embedded in direct contact with one another, the contacting surfaces shall be heavily coated with bituminous mastic or other Owner-approved surface treatment to prevent galvanic coupling.

K *Mixing Concrete:*

i The mixer and mixing time shall be in accordance with ACI 304. Hot weather concreting shall comply with ACI 305R, and cold weather concreting with ACI 306R.

ii No additional water shall be added to batched concrete without the permission of the Owner. The water shall be incorporated by additional mixing equal to at least half of the total mixing required for the batch. Any addition of water above that permitted by the limitation on water-cement ratio shall be accompanied by a quantity of cement sufficient to maintain the proper water-cement ratio.

iii Concrete shall be mixed only in such quantities as are required for immediate use. The maximum allowable time between charging of the material in the mixing drum and final placing for mean ambient temperatures below 90oF shall be ninety (90) minutes or 300 drum revolutions, whichever comes first. Concrete to be delivered when the mean ambient temperature exceeds 90oF shall be mixed and delivered in accordance with the requirements of ACI 305 "Recommended Practice for Hot-Weather Concreting". Concrete not placed within these time limits, or if an initial set has developed, shall not be used. Tempering concrete by adding water or by other means will not be permitted.

3.1 Placing Concrete:

A. Concrete shall not be placed prior to a recorded pre-placement inspection and/or authorization to proceed by the Owner representative.

B. Concrete delivered without batch tickets shall not be accepted. Copies of concrete delivery tickets shall be provided to the inspector.

C. The slump may be increased up to 6 inches if concrete pumping is to be used. The proposed mix design for pumped concrete shall be approved by the Owner representative.

D. Conveying and placing of concrete shall be in accordance with ACI 304.

E. Each day's pour shall be properly scheduled to assure that concrete surfaces can be finished correctly and the use of cold joints can be minimized.

F. All concrete shall be mechanically vibrated, except for slabs on grade that are six inches or less in thickness. See specification 02200 for concrete consolidation requirements for drilled piers.

G. Concrete shall be placed in layers not over 24 inches deep. Each layer shall be consolidated by mechanical internal-vibrating equipment supplemented by hand spading, rodding, and tamping to work concrete into all angles and narrow places. Duration of vibration shall be limited to time necessary to produce satisfactory consolidation without causing objectionable segregation. Vibrators shall be applied vertically and at uniformly spaced points not farther apart than the visible effectiveness of the machine. The vibrator shall not be inserted into lower courses that have begun to set. Vibrators shall not be used to transport concrete inside forms. The use of form vibrators or form tamping will not be permitted and shall be in accordance with ACI 309R.

H. The free fall on concrete from the end of the spout or chute, or from a transporting vehicle, shall not exceed 10 feet for thin walls (10 inches or less in thickness) or more than 5 feet for other types of construction.

I. A tremie or flexible metal spout shall be used when the distance through which concrete must be dropped vertically exceeds the maximum specified above. Flexible metal spouts shall be composed of conical sections not more than three feet long, with the diameter of the outlet and the taper of the various sections such that the concrete will fill the outlet and be retarded in its flow.

J. Chutes, troughs, or pipes used as aids in placing concrete shall be arranged and used so that the ingredients of the concrete will not be separated. Chutes and troughs shall be of metal or metal-lined. When steep slopes are necessary, the chutes shall be equipped with baffle boards or a reversed section at the outlet. Open troughs and chutes shall extend, if necessary, down inside the form or through holes left in the forms; or the ends of such chutes shall terminate in vertical downspouts. All chutes, troughs, and pipes shall be kept clean and free from coatings or hardened mortar by a thorough flushing with water before and after each placement. Water used for flushing shall be discharged outside of the forms.

K. The concrete shall be deposited, as nearly as possible, in its final position and shall not be caused to flow laterally in the form any considerable distance. Each pour shall be completed in a continuous operation with no interruptions in excess of forty-five minutes. Each layer shall be placed and compacted before the preceding layer has taken initial set.

L. The placing sequence shall always be arranged to allow for the effects of settling and shrinkage. Walls 10'-0” and over in height shall be stopped about 1 foot short of the top and allowed to settle one hour minimum before topping out. Walls and columns bearing superimposed slabs or beams shall be allowed to settle a minimum of two hours before pouring slabs or beams. Laitance shall be removed before pouring superimposed structural members.

3.2 Bonding:

A. The existing surfaces shall be thoroughly cleaned of all foreign material and laitance before depositing new concrete on old concrete or against concrete which has set. Existing surfaces shall be coated with a bonding agent in accordance with ASTM specification C 881 (Sika Chemical Corporation’s Sikadur 32, High-Mod structural epoxy adhesive meets this specification).

3.3 Joints:

A. Construction and control joints shall be placed as indicated on drawings.

B. Use of construction and control joints, not shown on the drawings, shall be in accordance with ACI 318, Chapter 6.4, and subject to approval of the Owner representative.

C. Waterstops shall be installed as shown on the drawings, forming a continuous diaphragm in each joint. Support for waterstops shall be provided and waterstop material shall be protected from damage. Field joints in waterstops shall be fabricated in accordance with manufacturer's instructions.

D. Saw cutting of contraction joints shall be done as soon as concrete hardens sufficiently (normally 4-12 hours) so as not to be torn or damaged by the blade. Sawing shall not be done while concrete temperature is falling. Construction and control joints shall be filled with an approved sealant with pre-molded joint filler and backer rod as shown on the drawings.

E. Joints not specified on the design drawings shall be in accordance with ACI 301, Chapter 6, and Section 11.5.

F. All reinforcing shall be continued across construction joints. Keys shall be provided only if required by the design drawings.

G. When called for on the design drawings, the concrete surface at construction joints shall be roughened uniformly to approximately 1/4 inch. Laitance, loosened aggregate or damaged surface concrete shall be removed.

H. Paving or slab construction joints, when not specified on the design drawings, shall be located at column centerlines and at intermediate intervals so that each panel shall be not more than 400 square feet in the area, unless slab is reinforced, in which case the area shall not be more than 600 square feet. Maximum spacing of construction joints in un- reinforced slabs shall not exceed twice the slab thickness in inches (i.e., 6 inch slab: 12 feet) nor 1-1/2 times the width for narrow slabs such as sidewalks. Concrete shall be placed in checkerboard patterns or in alternate paving lanes utilizing construction and contraction joints to provide panels of the size shown on the drawing (when shown).

3.4 Finishing Concrete:

A. Form ties shall be broken back 1 inch from the surface of the concrete. Seal patching using 1-to-2 mix of cement-sand mortar shall fill the remaining holes.

B. All voids and honeycomb in formed concrete shall be filled with a 1-to- 2 cement-sand mortar mix. Form ridges and other projections shall be removed immediately, after forms are removed. Exposed form concrete shall be rubbed with a carborundum brick and a thin cement grout shall be applied as necessary to produce a true, even, finished surface. Grout shall extend at least 3" below finished backfill grade on grade walls.

C. Concrete surfaces left low for grouting shall be roughened to expose aggregate and all loose particles and laitance removed. Anchor rod threads shall be wire brushed, and greased, after concrete has set. Nuts and washers shall be placed on the rods.

D. Finish for Floors and Walls:

1. Interior building slabs including pit floors shall be screeded, floated, and steel trowelled.
2. Exterior slabs shall be screeded, floated, trowelled, and broomed.
3. Special care shall be exercised on floors that have drains or trenches. Floors shall be sloped uniformly to provide even fall for drainage.

D. Screeding, Floating, Troweling, Brooming & Nonslip Finishing:

1. Surfaces shall be screeded to the elevations shown on the drawings. "Con-Film" or Owner-approved equal shall be sprayed on the screeded surface in conformity with manufacturer's directions if the air temperature is expected to reach 80^{o}F or above before cure is complete.
2. Floating shall start as soon as the screeded surface has stiffened sufficiently. Floating shall be performed as necessary to produce a smooth, even, textured finish. Floating shall be performed by hand using magnesium tools.
3. The slab surface shall be tested for accuracy with a straight edge after the first floating finish is completed. Any depressions shall be filled and high areas shall be cut down and reworked. Straight edge testing and refloating shall continue until there are no deviations of more than 1/8 inch under a ten-foot straight edge.
4. Interior slabs shall be troweled except as noted on drawings or specified otherwise. Steel troweling shall begin after straight edge testing is finished and while concrete is still green, but sufficiently hardened to bear a person's weight without deep imprint. Steel troweling shall produce a smooth troweled finish per ACI Standard 301, Section 11.7.3 "Trowel Finish". Time lapse and number of trowelings to produce a hard surface will vary depending on weather conditions.
5. Exterior slabs and other surfaces, as noted, shall be broomed after final floating to provide a nonskid surface. A soft bristled push broom shall be used, with a swirling motion.
6. Surfaces indicated shall have a nonslip finish obtained by sprinkling not less than 1/4 pound of abrasive aggregate over each square foot of the screeded and floated concrete, and finishing immediately with a steel trowel. The abrasive aggregate shall consist of not less than 55 percent aluminum oxide or silicone-carbide abrasive ceramically bonded together to form a homogeneous material that will be sufficiently porous to provide a good bond with Portland cement. The aggregate shall have an abrasive hardness of not less than 40 as determined by the test for wear resistance in the National Bureau of Standards Report BMS 98.

3.5 Curing and Sealing:

A. All finished concrete shall be cured by a curing method compatible with the final floor finish for a minimum of 7 days in accordance with ACI 301 Chapter 12. One or more of the following methods may be used, if approved by the Owner, except where specified curing method is called for:

1. Water curing by ponding or continuous wetting of sand or burlap.
2. Form curing by leaving on the forms and wetting for seven days.
3. An approved sprayed on curing compound applied in accordance with the manufacturer's instruction.
4. Steel troweled floor slabs, not covered with other materials shall receive a coat of Cenco Seal 301 surface hardener applied after all other equipment and work in the building has been installed and/or

completed and the floor has been thoroughly cleaned of all dust, dirt, masks, and foreign matter. Floor surfaces designated to receive tile or other treatment shall not be treated with sealers or hardeners.

3.6 Cold Weather Concrete:

A. Thorough preparation for protection against cold weather damage to concrete shall be made well in advance. Cold weather concreting shall be performed in accordance with ACI 306R.

B. Concrete shall be protected from freezing for not less than the first 48 hours after placing after the first frost, or when the mean 24-hour temperature at the job site falls below 40^{o}F.

C. The placing temperature of the concrete shall be maintained above 50^{o}F when the mean 24-hour temperature falls below 40^{o}F.

D. The temperature of fresh-placed concrete shall be between 50 and 60^{o}F.

3.7 Hot Weather Concrete:

A. Thorough preparation for protection against hot weather damage to concrete shall be made well in advance. Hot weather concreting shall be performed in accordance with ACI 305.

B. The maximum concrete temperature, at time of placement, shall be limited in accordance with ACI 305, Figure 2.1.4. The evaporation rate of the mixing water shall not exceed 0.2 pounds of water per square foot per hour.

C. One or more of the ingredients may have to be cooled to keep the temperature of the concrete from being excessive at time of placement. The replacement of part of the mixing water with an equal weight of crushed ice is recommended for effective cooling per ACI 305, figure 2.3.6.

D. In-place concrete shall be protected and cured so as to minimize drying and absorption of heat.

3.8 Pumped Concrete:

A. The Owner shall approve the use of pumped concrete in each case.

B. The proposed mix design for each class of concrete to be pumped, including all necessary background data of test results, shall be submitted to the Owner for approval.

C. All slump and cylinder test samples shall be taken from the end of the discharge line.

3.9 Testing and Inspection:

A. Testing and acceptance of tests of concrete shall be done in accordance with ASTM C 31, C 39, C 94, C 143, C 172, and C 173, D 75 and C 136.

B. A testing laboratory engaged by the Owner will be responsible for:

1. Supplying the test cylinder molds to the job-site and taking the cylinder samples.
2. Testing for air, slump, temperature, compression strength and aggregate gradation.
3. Preparing test reports.

C. The Contractor shall supply concrete for all tests.

D. Concrete shall be sampled, cured, tested and accepted for compressive strength in accordance with ASTM C 172, C 31, C39, and C 94. Compressive test cylinders shall be prepared in sets of three cylinders for each test. Specimens for each set shall be obtained from the same batch of concrete after about one half of the batch has been placed in the forms. The rate of sampling shall be as follows:

1. Structures and Foundations and Slabs on Grade
   One set per 50 cubic yards of concrete or one set at the beginning of each days concreting.

2. Underground Duct Envelopes and Fireproofing
   One set taken at the beginning of concreting work. Subsequent testing may be performed at the discretion of the Owner representative.

3. All Other Concrete
   See Paragraph 3.14.D.1 above.

E. Test cylinder sets shall be dated, numbered consecutively, and identified as to location.

F. All cylinders shall be immediately stored under wet sand or burlap for about 24 hours after preparation. All vibration or impact shall be avoided during this critical period.

G. After initial storage, the cylinders (still in their molds) shall be packed in sealed polyethylene bags, wet sand or other resilient material for shipment to the testing laboratory.

H. Concrete slump tests shall be made in accordance with ASTM C 143 and shall be taken as necessary to assure well-placed concrete.

I. In-Place Tests: Where questions as to the quality of the concrete placed, Owner representative may require tests per ASTM C 42 or order a load test on structures as outlined in Chapter 20 of ACI 318, Building Code Requirements for Structural Concrete.

J. Inspection: All forms, reinforcement, and anchor rods shall be inspected and approved by the Owner representative before concrete is placed. If work is found unsatisfactory, the work shall not proceed until all defects have been remedied. The Owner representative shall approve repaired work. Such approval will in no way relieve the Contractor of his obligation to produce finished concrete as required by the drawings and specifications.

3.10 Submittals:

Three (3) copies of the following shall be submitted to the Owner representative for review before proceeding:

A. MIX DESIGN: Design of concrete mixes in accordance with this specification and ACI 301, Chapter 3.

B. Copies of concrete delivery batch tickets.

C. SHOP DRAWINGS: Reinforcing steel shop drawings, bar lists and bending and erection drawings.

D. TEST REPORTS: Test Reports and material certifications as noted elsewhere in this specification.

21. SECTION 3010 CONTROLLED DENSITY FILL

1.0 General

1.1 Scope

The work covered by this specification includes furnishing of all labor, equipment and materials required for placement of non-settling backfill mixtures described as a Controlled Low Strength Material-Controlled Density Fill. Hereafter referenced by the acronym: CLSM-CDF. (Fill mixtures are sold commercially under a variety of producer names: K-Krete®, M-Crete, Darafill®, Flash Fill®, Flowable Fill, Flowable Mortar, Unshrinkable Fill, etc.) CLSM-CDF is used as a low strength, high slump self-consolidating fill material that provides support strength for traffic loads and which can be easily excavated at a later time. It may be used as a trench backfill, structural backfill, pipe bedding, or pipe filling for abandonment in place.

1.2 Codes and Standards:

ACI SP-150	Controlled Low-Strength Material ACI 229R Controlled Low-Strength Materials
ASTM C33	Standard Specification for Concrete Aggregates
ASTM C150	Standard Specification for Portland Cement
ASTM C618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM D6103	Standard Test Method for Flow Consistency of Controlled Low Strength Material (CLSM)
ASTM D6023	Standard Test Method for Unit Weight, Yield, Cement Content and Air Content (Gravimetric) of Controlled Low Strength Material (CSLM)
ASTM D5971	Standard Practice for Sampling Freshly Mixed Controlled Low Strength Material
ASTM A 674	Standard Practice For Polyethylene Encasement for Ductile Iron Pipe for Water or Other Liquids
ASTM D 1558	Standard Test Method for Moisture Content Penetration Resistance Relationship of Fine- Grained Soils
ASTM D 4832	Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders
ASTM D 5084	Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

1.3 Submittals

A. Before manufacture of any CLSM-CDF mixture, the Contractor shall comply with the following requirements.

B. Demonstrate the ability to produce a uniform CLSM-CDF mixture as outlined in this specification. The National Ready Mix Concrete Association's (NRMCA) plant and truck certification will satisfy the producer certification requirement.

C. Certified engineering data, for the proposed mixture to be used, shall be submitted for twenty eight (28) and ninety (90) day unconfined compressive strength (C') tests as described in ASTM D 4832, except that cylinders will not be capped.
D. Yield and dry unit weight (ASTM D6023)
E. Flowability (ASTM D6103)
F. Removability (Removability Modulus RE =<1.0)
G. Mixture's components (cement, water, fly ash, filler aggregate etc.) and sources (company and location): Previous test results, on the same mixtures using the same mixture components, will satisfy this requirement. If it is determined, that for the engineering data presented, flowability, adequate strength, and removability requirements are not acceptable, the use of this mixture will not be allowed.

22. 2.0 Materials

CLSM-CDF Materials

Materials for CLSM-CDF mixtures will be the responsibility of the Contractor. All mixture components must be environmentally acceptable. A Material Safety Data Sheet (MSDS) for each component in the mixture must be available upon request.

Materials for CLSM-CDF mixtures shall be evaluated as non-corrosive by appropriate ASTM standards including ASTM A 674. If the CLSM-CDF mixture has an electrical resistivity value of less than 5000 W cm, then to ensure compatibility with any proposed or encountered metal conduit, a polyethylene encasement shall be required conforming to ASTM A 674.

The CLSM-CDF shall have a 28 day unconfined compressive strength of 50 psi to a maximum of 100 psi. Total air content shall not exceed 30 percent. The mix shall have a flow of 6 to 8 inches when tested in accordance with ASTM D6103. Pumpable CLSM-CDF shall be proportioned to allow transport by pumping methods without segregating or excessive bleeding.

2.1 Portland Cement: ASTM C150, Type I or Type II.
2.2 Fly Ash: ASTM C618, Class F. Fly ash shall not inhibit air entrainment.
2.3 Air-Entraining Admixture: ASTM C260
2.4 Aggregate: ASTM C33, graded aggregate, maximum size of 3/8 inch, and the 3/8 inch aggregate shall comprise no more than 20 percent of the total aggregate. Amount passing a No. 200 sieve shall not exceed 12 percent. No plastic fines shall be present.
2.5 Water: Water used for the mixture shall be free from oil, salts, acid, strong alkalis, vegetable matter, and other impurities that would have an adverse effect on the quality of the backfill material.

23. 3.0 Materials

3.1 Proportioning of Mixtures

The proportioning of CLSM-CDF mixtures is the responsibility of the Contractor. The mixture will be rejected for failure to meet, or sustain, the mixture's consistency for the previously stated properties.

Where gas leak, odor migration, is a concern for the identification of possible gas leaks, the CLSM-CDF material shall meet a minimum permeability coefficient (k) of one x 10-5 (cm/sec), or more, based on ASTM D 5048.

3.2 Placing (Pouring)

The CLSM-CDF mixture shall be placed directly into the trench or excavation. The material's flow characteristic will be such that no labor will be required in the trench or excavation. No vibration or compaction equipment shall be used. If the trench or excavation contains water, the CLSM-CDF mixtures may be used to displace the water.

A Fast Setting Mixture shall be used for backfilling trenches under pavement when it is deemed that the pavement must be quickly reopened to traffic so as to minimize inconvenience to vehicular traffic as shown on the plans. The use of a Fast Setting Mixture is intended to allow for placement of an asphaltic concrete pavement within two hours after mixture placement. Fast Setting Mixture shall produce a load bearing strength of 20 psi in two hours as measured with a penetrometer using the 1.124" diameter head (ASTM D 1558).

3.3 Construction Requirements

The trench or excavation shall have vertical wall limits that confine the flowable CLSM-CDF mixture in a given area. For long trenches, requiring large amount of CLSM-CDF material, bulkheads can be used to control required placement quantities.

The CLSM-CDF material shall be brought up uniformly to the lines or limits shown on the plans or as directed by the Engineer. The placing of Portland cement concrete and/or asphaltic concrete pavements can be performed when a load bearing strength of 20 psi is achieved as referenced in Section 3.2.

A. The following limitations of operations shall govern:
   1. The mixtures shall not be placed on frozen ground.
   2. The placed mixtures shall be protected from freezing.
   3. Each filling stage shall be as continuous as possible.
   4. Setting time of CLSM-CDF may be affected by temperature. At temperatures near freezing, or below, additional time may be needed for proper setting of the material prior to any type of paving operation.

3.4 Acceptance of Material and Field Test Requirements The material acceptance will be

based on the following.

A. Contractor certification (Section 03010.1.3)
B. Field testing for flowability (ASTM D6103)
C. Sampling freshly mixed CLSM (ASTM D5971)
D. Cylinder (3" x 6") strengths (ASTM D 4832). Six (6) cylinders will be required for any placement of 50 cubic yards and each 50 cubic yards thereafter. Three (3) cylinders will be broken at 28 and three at 90 days. If the placement is less than 50 cubic yards, three (3) cylinders will be taken every day of production. Two cylinders will be broken at 28 days and one (1) cylinder at 90 days.
   The Contractor shall be responsible for the curing and protection of the cylinders until such time that they are ready to be picked up by the testing

laboratory. The Contractor shall coordinate this activity. A testing laboratory will hold the cylinders until the required breaking date.

E. Unit weight tests (ASTM D6023) will be performed when cylinders are made. All tests shall be performed by laboratories approved by the Owner. Copies of all test reports shall be submitted to the Owner. If the produced CLSM- CDF material fails any of these acceptance tests, indicating future removal difficulty (RE > 1.0), the material will be rejected with the possibility of removal. All CLSM-CDF tests are to be performed by qualified testing personnel.

24. SECTION 3020 CONCRETE REPAIR

1.0 General

1.1 Scope

The work covered by this specification includes furnishing of all labor, equipment and materials required for the preparation of damaged concrete foundations and application of repair materials.

1.2 Submittals

A. Submit under provisions of Section 01300 the following information.

B. Product Data: Indicate product standards, physical and chemical characteristics, technical specifications, limitations, maintenance instructions, and general recommendations regarding each material.

C. Manufacturer's Certificate: Certify that specified products meet or exceed specified requirements.

1.3 Qualifications

A. Materials Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three years documented experience.

1.4 Delivery, Storage, and Handling

A. Deliver, store, protect and handle products under provisions of manufacture instructions for storage, shelf life limitations, and handling.

25. 2.0 Products

2.1 Manufacturers

A. Mortar: Sika Corporation; Product SikaRepair SHA

B. Steel Primer: Sika Corporation; Product SikaArmatec 101 EpoCem

C. Latex: Sika Corporation; Product SikaLatex (R)

D. Substitutions: All substitutions shall meet the specifications below and be approved by the Owner.

2.2 Patching Materials

A. Patching material shall be a fast setting, on component, cementitious repair mortar meeting the following minimum characteristics:

Characteristic	Test Method	Results
Bond Strength	ASTM C 882 (Modified)	1,800 psi
Flexural Strength	ASTM C 293	1,100 psi
Compressive Strength	ASTM C 109	5,000 psi at 28 days

B. Reinforcement primer shall be moisture-tolerant, epoxy-modified, cementitious product specifically formulated as a bonding agent and an anti- corrosion coating.

Characteristic	Test Method	Results
Splitting Tensile Strength	ASTM C 496	600 psi at 28 days
Flexural Strength	ASTM C 348	1,250 psi
Compressive Strength	ASTM C 109	8,500 psi at 28

C. Acrylic-polymer latex, shall be a general-purpose admixture to produce polymer-modified concrete and mortar.

Characteristic	Test Method	Results
Bond Strength	ASTM C 882	>500 psi

2.3 Mixing Cementitious Materials

A. Mix cementitious mortar in accordance with manufacturer's instructions for purpose intended.

B. Include latex polymer as a substitute for mixing with water.

26. 3.0 Execution

3.1 Surface Preparation

A. Remove all deteriorated, broken and soft concrete. Cut all edges to sound surface concrete to a minimum depth of ¼-in. Clean concrete and exposed reinforcing steel surfaces of corrosion from steel, dirt, oil, grease, laitance, corrosion, or other contamination by high-pressure water blast, scabbler, wire brush or other appropriate mechanical means. Concrete shall obtain an aggregate fractured surface profile of 1/16-in. Rinse surface, flush out cracks and voids and allow to dry to a saturated surface dry (SSD) condition with no standing water.

3.2 Application of Cementitious Mortar

A. Apply the mixed cementitious mortar by working it well into the primed surface, filling all pores and voids. Compact well. Force the material against edge of repair working towards the center, thoroughly compacting towards the center. If multiple lifts are required, score the top surface on each lift and allow the lift to harden before applying fresh material. The final surface shall be finished smooth with steel trowel.

B. Cure as per ACI recommendations for Portland cement concrete. Curing compounds must be pretested for compatibility. Protect fresh mortar form direct sunlight, wind, rain and frost.

4 Fencing

27. SECTION 4000 FENCING AND GATES

4.1.1 General

4.1.2 Scope

This section includes specifications for furnishing all materials, labor, tools, and equipment necessary to construct the substation perimeter fence and gates.

4.1.3 General Requirements

The project substation perimeter shall be fenced. The fence shall be tied into the project substation grounding grid.

At least one (1) vehicle gate shall be installed at the project substation. The vehicle gate shall be a 20-foot-wide (minimum), manual, rolling, locking gate. At least 10 remote-entry devices shall be supplied and programmed by Contractor for Owner's use.

At least one (1) pedestrian gate shall be installed at the project substation. The pedestrian gate shall be a 4-foot-wide (minimum), locking, manual swing-gate for personnel access.

Contractor shall furnish and install a contact sign at the entrance to the Project Substation.

A minimum of six (6) inches of washed crushed aggregate shall cover the entire project substation footprint, including those areas reserved for future build-out, plus a minimum of three (3) feet outside the perimeter fence, to help reduce touch and step potentials. A greater level of washed crushed aggregate shall be installed if necessary to meet applicable requirements and satisfy the recommendations set forth in the geotechnical Report. Any areas at the Project substation to be utilized for traffic must be suitably compacted to support traffic loads.

Fence and gates shall comply with M1-01-07 (Security and Compliance).

The fence shall be tied into the Project Substation grounding grid.

vehicle gate shall be installed at the Project Substation. The vehicle gate shall be a 20-foot-wide (minimum), [motorized/manual], rolling, locking gate. one (1) pedestrian gate shall be installed at the Project Substation.

4.1.4 Materials

4.1.5 Concrete

Reinforced concrete for the fence and gate foundations shall meet the requirements of Section 3000 Reinforced Concrete.

4.1.6 Execution

Perimeter fence and gates shall be installed in accordance with drawings provided by the Owner.

5 Metals

28. SECTION 5100 STRUCTURAL STEEL FABRICATION

5.1.1 General

5.1.2 Scope

The work covered by this specification includes furnishing of all labor, equipment and materials required for fabrication of structural steel as shown on the drawings and specified herein.

5.1.3 Codes and Standards

Comply with the provisions of the following codes, specifications and standards, except as otherwise shown or specified. The latest edition of the code or standard shall govern.

ASTM A6	Standard Specification for General Requirements for Rolled Steel Plates, Shapes, Steel Piping, and Bars for Structural Use
ASTM A36	Standard Specification for Carbon Structural Steel ASTM A53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless (Grade B type E or S only)
ASTM A143	Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement
ASTM A307	Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength
ASTM A325	Standard Specification for Structural Bolts, Steel, Heat Treated, 120/205 ksi Minimum Tensile Strength
ASTM A500	Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A563	Standard Specification for Carbon and Alloy Steel Nuts ASTM A572 Standard Specification for High-Strength Low-Alloy Columbium- Vanadium Structural Steel
ASTM A992	Standard Specification for Structural Shapes
ASTM A1011	Standard Specification for Steel, Sheet and Strip, Hot- Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability (replaces A 570)
ASTM F436	Standard Specification for Hardened Steel Washers American Institute of Steel Construction (AISC) "Code of Standard Practice for Steel Buildings and Bridges", AISC 303.

American Institute of Steel Construction (AISC) “Specification for Structural Steel Buildings” including “Commentary”, ANSI/AISC 360.

American Institute of Steel Construction (AISC) “Specification for Structural Joints Using ASTM A325 or A490 Bolts”, Prepared by Research Council on Structural Connections (RCSC) Committee A.1.

American Welding Society "Structural Welding Code - Steel D 1.1"

5.1.4 Submittals

A. Contractor shall submit manufacturer’s mill certificates certifying that products meet or exceed specified chemical composition, yield strength and other specified requirements.

B. Where Owner provided drawings are not sufficiently detailed for fabrication or where Contractor produces drawings for fabrication purposes, such drawings shall be issued to Owner for review and approval prior to fabrication.

5.1.5 Materials

All materials shall conform to the following specifications unless otherwise approved by Owner

W-Shapes	ASTM A992
Misc. Channels	ASTM A36
Channels	ASTM A36
Angles	ASTM A36
Plates & Bars	ASTM A36
Plates for Tubular Sections	ASTM A572 Grade 65 Sheets
	ASTM A1011 CS Type B
HSS (Rectangular)	ASTM A500 Grade B
HSS (Round)	ASTM A500 Grade B
Pipe	ASTM A53 Grade B,

All steel shall have a silicon content between 0.0% - 0.04% or 0.15% - 0.25% only

Bolts	ASTM A325 Type 1
	ASTM A307 Grade A
Nuts	ASTM A563 Grade DH
Washers	ASTM F436 Type 1

5.1.6 Execution

5.1.7 General

All workmanship and finish shall be equal to the best modern practice for fabrication of structural steel. All parts of the structure shall be neatly finished and free from kinks or twist. All holes, blocks and chips shall be clean-cut without torn or ragged edges. Fabrication shall be in strict accordance with detail drawings. Welding of two or more pieces to obtain the length of a member will not be accepted.

Structural steel shall be fabricated in accordance with the following requirements:

A *Straightening Material: Structural steel shall be straight and shall be clean of all rust before being laid off or worked in any manner. Straightening of material shall be done by a method that will not injure the metal.*

B *Shearing and Cutting: Shearing and cutting shall be performed so that edges are not distorted or jagged; and all edges that will be exposed to view shall have a smooth finish. Copes and re-entrant cuts shall be filleted before cutting.*

C *Holes: All holes shall be cylindrical and perpendicular to the member's surface.*

D *To avoid hole distortion, holes close to the points of bend shall be made after bending. The use of burning torch for cutting holes will not be permitted. Punched holes shall be made with a punch that is equal to the diameter of the specified hole, and the die shall be not more than 1/16" larger than the diameter of the punch.*

E *Hole Correction: Misdrilled or mispunched holes may be corrected by filling holes with weld and redrilling or punching. Welding shall be in accordance with AWS D1.1. The following procedure shall be used for filling holes:*

i All surfaces within the area of the weld shall be stripped of galvanizing and free from scale, slag, rust, grease or other foreign material that will prevent proper weld.

ii Electrodes used shall be of a classification that will provide weld metal of the tensile strength of the base metal being welded.

iii Welds shall be made in a flat position with the use of a suitable chill plate.

iv The arc shall be carried around the periphery of the hole and then in a spiral path to the center of the hole, fusing and depositing a layer of weld metal in the bottom of the hole. The arch shall then be carried back to the periphery of the hole and the procedure repeated, fusing and depositing successive layers to fill the hole. Slag covering the weld metal shall be kept molten until the weld is finished. If the arch is broken, the slag must be allowed to cool and be removed before restarting the weld.

v The surface of the completed weld shall be ground flush with the original surface prior to redrilling or repunching of the hole.

F *Welding: All welding shall be performed in accordance with the latest edition of the "Structural Welding Code" AWS D1.1. A shielded arc-welding process shall be used. All welds shall be of the type specified on the drawings and shall be made in such a manner that residual shrinkage stresses will be reduced to a minimum. For material to be galvanized; all welds shall completely seal; there shall be no voids or seams between adjoining surfaces into which pickling acids or other fluids may enter. The welding process and the welding operators employed in performing the work covered by these specifications shall be qualified, in accordance with American Welding Society Standard Qualification Procedure.*

G *Bending: The inside radius of cold bends in plates shall be: 3 times the thickness of plates up to 0.5 inches thick; 4 times the thickness of plates between 0.5 inches and 1.0 inches thick; and 6 times the thickness of plates between 1.0 inches and 1.5 inches thick. These cold bend radii may be* *reduced by 50% when the bend lines are transverse to the direction of the plate rolling. Angles and other sections requiring tension bends of the out-standing element greater than 3.375:12 or compression bends of the outstanding element greater than 5.625:12 shall be formed by cutting and welding one leg of the angle or the flanges of the section.*

H Marking: All individual pieces shall be marked clearly with the correct designation shown on the drawings. The marks shall be stamped into each piece with a ½" high metal die before galvanizing; and the letters shall be clearly legible after galvanizing. In addition, all piece marks shall be circled with water-resistant marking pen after galvanizing.

I Inspection: All material shall be subject to inspection. Contractor shall notify Owner after completion of fabrication and before galvanizing that the structures are complete and ready for inspection. Owner will have the option to waive inspection or will have 72 hours to inspect the structures before they are sent to be galvanized. This inspection or waive of inspection by Owner shall not relieve Contractor from entire responsibility for materials, workmanship, and all other liabilities under the contract.

Final inspection will be at the site of construction after complete installation. Final acceptance will be after the material has been completely installed and found to comply with all requirements of the specifications.

Contractor shall notify Owner of all discrepancies and drawing errors found during fabrication.

29. SECTION 5110 ANCHOR RODS

5.1.8 General

5.1.9 Scope

The work covered by this specification includes the requirements for furnishing, detailing, fabrication, delivering and installing anchor rods including nuts, washers, anchor rod sleeves and accessories.

5.1.10 Codes and Standards

Comply with the provisions of the following codes, specifications and standards except as otherwise shown or specified. The latest edition of the code or standard shall apply.

American Institute of Steel Construction (AISC) "Code of Standard Practice for Steel Buildings and Bridges", AISC 303.

American Institute of Steel Construction (AISC) "Specification for Structural Steel Buildings" including "Commentary", ANSI/AISC 360.

ASTM A6	Standard Specification for General Requirements for Rolled Steel Plates, Shapes, Steel Piping, and Bars for Structural Use
ASTM A53	Standard Specification for Pipe, Steel, Black and Hot- Dipped, Zinc-Coated Welded and Seamless (Grade B type E or S only)

ASTM A153	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM F436	Standard Specification for Hardened Steel Washers ASTM A563 Standard Specification for Carbon and Alloy Steel Nut ASTM F1554 Standard Specification for Anchor Bolts, Steel, 36, 55, and 150- ksi Yield Strength American National Standards Institute (ANSI):

B1.1, Unified Inch Screw Threads

B18.2.2, Square and Hex Nuts (Inch Series)

5.1.11 SUBMITTALS

The Contractor shall submit two copies of material certifications and shop detail drawings to confirm that anchor material supplied is in conformance with applicable codes and standards, this specification and the design drawings.

5.1.12 QUALITY ASSURANCE

Manufacturer's material certificates or the mill test reports, as required by the applicable codes or standards, shall be submitted to the Owner with the delivery of the anchor rods to the project site.

5.1.13 MATERIALS

A Unless noted otherwise on the drawings, materials shall be in accordance with the following.

Anchor Rods	ASTM F1554 Grade 55
Sleeves A563 Washers	ASTM A53 Grade B Nuts (Heavy Hex) ASTM ASTM F436
Anchor Plates	ASTM A36

B Galvanizing for anchor rods, nuts, washers, sleeves and plates shall be in accordance with Specification Section 05140 Hot Dip Galvanizing.

5.1.14 EXECUTION

A General

Installation of anchor rods shall be in accordance with AISC Code of Standard Practice for Steel Buildings and Bridges, Section 7.5

B Protection of Anchor Rods

Anchor rod threads shall be protected against damage. Damaged anchor rods shall be repaired or replaced. Welding (including tack welding) to anchor rods is **not permitted**.

C Setting of Anchor Rods

Templates shall be provided for all anchor rods. Templates shall be designed and constructed of sufficiently thick and rigid material to hold the rods to the lines and elevation as set.

Anchor rods shall be accurately located and set to the line and elevation before concrete is poured. Accuracy of position of anchor rods shall be maintained throughout the placing and finishing of concrete.

Anchor rods shall not vary from the dimensions on the erection drawings by more than the following:

1/8” center to center of any two rods within an anchor group or individually from the dimension line

¼” center to center of adjacent anchor rod groups

½” elevation of the top of anchor rods

¼” maximum accumulation of error per hundred feet along established line

D Leveling Nuts:

Leveling nuts shall NOT be used unless noted specifically on drawings provided by Owner. Structures shall be set directly on foundations.

If use of leveling nuts is specified, the leveling nuts shall be set to the required elevation. The space between the bottom of the leveling nut and the top of concrete shall not exceed one anchor rod diameter. A flat washer shall be set on top of the leveling nut prior to setting the structure.

E Tightening

Nuts for anchor rods shall be brought to a snug-tight condition, followed by an additional one-quarter of a full turn. Snug-tight is defined as the tightness attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench.

30. SECTION 5120 STRUCTURAL STEEL ERECTION

1.0 General

1.1 Scope

The work covered by this specification includes the furnishing of all accessories, tools, equipment, services, scaffolding, transportation, labor and supervision necessary for the erection of fabricated steel.

1.2 Codes and Standards

Comply with the provisions of the following codes, specifications and standards except as otherwise shown or specified. The latest edition of the code or standard shall govern.

American Institute of Steel Construction (AISC) "Code of Standard Practice for Steel Buildings and Bridges”, AISC 303.

American Institute of Steel Construction (AISC) “Specification for Structural Steel Buildings” including “Commentary”, ANSI/AISC 360.

American Institute of Steel Construction (AISC) “Specification for Structural Joints Using ASTM A325 or A490 Bolts”, Prepared by Research Council on Structural Connections (RCSC) Committee A.1.

American Society of Testing and Materials, (ASTM), as noted in the specification American Welding Society, (AWS), Structural Welding Code - Steel D 1.1

1.3 Storage and Handling

Contractor shall store materials to permit easy access for inspection and identification. Steel members shall be stored off the ground. Protect steel members and packaged materials from corrosion and deterioration.

31. 2.0 Materials

2.1 Miscellaneous Materials

A. Electrodes for Welding - AWS A5.1, Class E70 Series

B. Wedges, shim packs and other adjusting devices.

2.2 Corrections of Shop Errors

The erector shall perform moderate amounts of reaming, chipping and cutting to allow proper fit-up of structural members. Any errors, which prevent the proper assembly of the structure, must be reported to the fabricator who is responsible either to correct the error or approve the most efficient and economical method of correction to be made by the erector. The cost of such corrections shall be borne by the fabricator.

2.3 Correction of Design Errors

If the erector deems a misfit of structural steel a design error the erector must notify Owner. If an error is determined, Owner shall provide resolution.

32. 3.0 Execution

3.1 Inspection

Observe areas and conditions under which structural steel is to be installed and notify Owner of conditions detrimental to the proper and timely completion of the work. Do not proceed until unsatisfactory conditions have been corrected and approved.

3.2 Erection

A. General

1. Comply with the AISC Specifications and Code of Standard Practice as herein specified. Erection tolerances as listed in the AISC Code shall apply unless otherwise specified herein or indicated on the drawings.
2. Verify elevations of bearing surfaces and locations of anchor rods before erection work proceeds. Do not proceed with erection until corrections have been made, or until compensating adjustments to the structural steel work have been made.

B. Setting Bases

1. Set base plates and bearing plates for structural members directly on foundation surface. Leveling nuts shall NOT be used unless otherwise indicated on the drawings. Shims shall be used as necessary to level and plumb structures.
2. Nuts for anchor rods shall be brought to a snug-tight condition, followed by an additional one-quarter of a full turn after the structural

steel is plumbed. Snug-tight is defined as the tightness attained by a few impacts of an impact wrench, or the full effort of a man using an ordinary spud wrench. The space between the bottom of the base plate and the top of the concrete shall not be grouted unless indicated otherwise.

C. Bracing

1. The erector is responsible for the stability of the structure during its erection.
2. Any bracing shown on the erection drawings has been designed to provide a stable structure upon the completion of erection. Permanent bracing shall be installed as each level of steel is erected.
3. The erector shall design and install all additional temporary bracing or guying required to meet loading imposed during erection, consistent with the erection sequence used, or required at the end of any work period to ensure safe and stable conditions.

D. Field Assembly

1. Set structural members in accordance with approved drawings accurately to the lines and elevations indicated. Align and adjust the various members forming a part of the complete frame or structure before permanently fastening. Before assembly clean bearing surfaces and other surfaces which will be in permanent contact.
2. Level and plumb individual members of the structure within specified AISC tolerances.
3. Splice members only where shown or specified.
4. Erection Bolts. On exposed welded construction, remove erection bolts, fill holes with plug welds and grind smooth at exposed surfaces.
5. Do not enlarge unfair holes in members by burning or by use of drift pins, except in secondary bracing members. Ream holes that must be enlarged to admit bolts.
6. Gas Cutting. Do not use gas cutting torches in the field for correcting fabrication errors in the structural framing. Cutting may be permitted only on secondary members and subject to the approval of Owner.
7. Provide temporary bracing or anchors in formwork for metal fabrications that are built into concrete or similar construction.

E. Installation of High Strength Bolts

1. Pretensioned Bolts. All high strength bolts shall be pretensioned by the Turn-of-Nut-Method as described in AISC Specification for Structural Joints Using ASTM A325 or A490 Bolts. Alternate methods that ensure pretensioned bolt installation shall be approved by the Owner. Bolts shall be installed in all holes of the connection and brought to a "snug tight" condition. Snug tightening shall progress systematically from the most rigid part of the connection to the free edges until all bolts are simultaneously snug tight and the connection is fully compacted.
   Following this initial operation, all bolts shall be tightened further by the application of the rotation specified in the following table:

33. Nut Rotation from Snug Tight Condition

	Disposition of Outer Face of Bolted Parts		
Bolt Length (underside of head to end of bolt)	Both faces normal to bolt axis	One face normal to bolt axis and other sloped not more than 1:20 (beveled washer not used)	Both faces sloped not more than 1:20 from normal to the bolt axis (beveled washer not used)
Up to and including 4 diameters	1/3 turn	½ turn	2/3 turn
Over 4 diameters but not exceeding 8 dia.	½ turn	2/3 turn	5/6 turn
Over 8 diameters but not exceeding 12 dia.	2/3 turn	5/6 turn	1 turn

Table Notes

i. Nut rotation is relative to bolt regardless of the element (nut or bolt) being turned. For required nut rotations of ½ turn and less, the tolerance is plus or minus 30 deg; for required nut rotations of 2/3 turn and more, the tolerance is plus or minus 45 degrees.

ii. This table is only applicable to connections in which all materials within the grip of the bolt are steel.

iii. During the tightening operation, there shall be no rotation of the part not turned by the wrench. Tightening shall progress systematically from the most rigid part of the joint to the free edges.

2. Snug-Tightened Bolts. When indicated in the drawings snug-tightened bolts shall be installed with locking devices such as lock washers or locknuts. Snug tight is defined as the tightness that exists when all plies are in firm contact and can be attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench.

F. Attachment to Existing Steel

1. Connections of new steel to existing shall be performed according to the drawings showing hole layout where existing steel must be drilled or punched to provide connections for new members.
2. All bolting of new steel to existing shall be made using high strength bolts (A 325 or A 490) unless otherwise indicated on the drawings.
3. Previously used high strength bolts shall not be reused but shall be replaced with new high strength bolts of the required size and length.

4. When shown on the drawings, connections of new steel to existing may be welded. All welding shall be performed in accordance with AWS Structural Welding Code - Steel D1.1.

G. Repair of Finish

1. After erection is complete, all protective coatings damaged during transportation and erection shall be touched in accordance with Specification 05130, "Painting of Structural Steel", or Specification 05140, "Hot Dip Galvanizing".

H. Inspection and Examination

1. All work is subject to inspection and examination by Owner for full compliance with all the requirements of this Specification and the design drawings.
2. Owner may retain the services of an independent inspection agency to perform inspections and examinations. Owner's testing agency will not be available for the erector Contractor's use.

34. SECTION 5130 PAINTING STEEL

1.0 General

1.1 Scope

The work covered by this specification includes furnishing of all labor, equipment and materials required for shop painting and field touch-up of fabricated steel.

1.2 Codes and Standards

Comply with the provisions of the following codes, specifications and standards except as otherwise shown or specified. The latest edition of the code or standard shall govern.

ASTM D16	Standard Terminology for Paint, Related Coatings, Materials, and Applications
NACE	Industrial Maintenance Painting
NPCA	Guide to U.S. Government Paint Specifications SSPC Steel

Structures Painting Manual

1.3 Submittals: Submit three copies of each requested item for review by the Owner.

A. Product Data: Provide data on all finishing products.

B. Samples: Submit 2 samples, ½ x 1½ inch in size illustrating selected color.

35. 2.0 Materials

2.1 Primer

Primer shall be Tnemec Typoxy Series 27WB or equivalent. Color shall be Gray (33GR), unless indicated otherwise on the drawings.

2.2 Top Coat

Top Coat shall be Tnemec Typoxy Series 27WB or equivalent Color shall be Gray (33GR), unless indicated otherwise on the drawings.

Coating system performance:

a) VOC: Un-thinned 11 grams per liter; thinned 25% 11 grams per liter HAPS 0 Lbs/gal per solids
b) Adhesion: Method ASTM D3359B Crosshatch Adhesion Requirement: No less than a rating of 5
c) Salt Spray (Fog): Method ASTM B117

2.3 Approved Manufacturer Information Tnemec Company Incorporated
P.O. Box 165770

North Kansas City,MO 64116 Phone: 1-800-TNEMEC-1

36. 3.0 Execution

3.1 Preparation

a) Bare Steel:
After fabrication, all steel shall be solvent cleaned of oil, grease, wax or other contaminants in accordance with SSPC SP-1. All welds shall be properly cleaned of slag and splatter removed. Surfaces to be painted shall be sandblast cleaned in accordance with SSPC SP-6 commercial blast.

b) Galvanized Steel:
All exterior surfaces shall receive a high-pressure wash – 3,000 psi at 3.5 gallons per minute minimum. Care should be taken not to damage or remove galvanizing. Rust should be removed from old galvanized steel by hand or power tool cleaning in accordance with SSPC-SP2 or SP3.

c) Field Retrofit of painted steel:
Remove all loose mill scale, loose rust, loose paint and other loose detrimental foreign matter by the use of power-assisted hand tools in accordance with SSPC SP3 requirements.

3.2 Application of Coatings

a) Shop Application on Bare Steel: All coatings shall be applied in the shop in strict accordance with paint manufacturer's instructions.
Apply one coat of Tnemec Typoxy, Series 27WB at 5.0 to 7.0 mils dry film thickness. This is a self-priming product. Additional coats may be applied as required or specified in the drawings.

b) Shop Application on Galvanized Steel: Apply one coat of Tnemec Typoxy, Series 27WB at 5.0 mils (minimum) dry film thickness.
c) Field Retrofit of painted steel:
Spot prime bare steel areas with on coat of Tnemec Typoxy Series 27WB at 3.0 to 5.0 mils dry film thickness. Apply top coat of Tnemec Typoxy Series 27WB at 5.0 to 7.0 mils dry film thickness.

3.3 Repair of Damaged Coating
Areas damaged during handling, transport or erection shall be cleaned with wire brush and coated with two coats of paint. Field repair shall only be performed during dry weather

conditions with temperatures above 50 degrees and below 90 degrees or as allowed by paint manufacturer.

37. SECTION 5140 HOT DIP GALVANIZING

1.0 General

1.1 Scope

The work covered by this specification includes furnishing of all labor, equipment and materials required for hot dip galvanizing of fabricated structural steel and fasteners.

1.2 Codes and Standards

Comply with the provisions of the following codes, specifications and standards, except as otherwise shown or specified. The latest edition of the code or standard shall govern.

ASTM A123	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A143	Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement
ASTM A153	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A384	Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies
ASTM A385	Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip)
ASTM A767	Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement
ASTM A780	Standard Specification for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

38. 2.0 Materials

2.1 Owner shall approve coating applicators.

2.2 Steel materials shall be geometrically and chemically suitable for galvanizing as described in ASTM A384 and A385. Steel materials suitable for galvanizing include structural shapes, pipe, sheet, fabrications and assemblies. Recommended steel materials for hot dip galvanizing include:

W-Shapes	ASTM A992
Misc. Channels	ASTM A36, A572 Grade 50
Channels	ASTM A36, A572 Grade 50

Angles	ASTM A36, A572 Grade 50
Plates & Bars	ASTM A36, A572 Grade 50 or 65
Sheets (Rectangular and Round)	ASTM A1011 CS Type B HSS ASTM A500 Grade B Steel Pipe ASTM A53 Grade B

All steel shall have a silicon content between 0.0% - 0.04% or 0.15% - 0.25% only

Bolts	ASTM A325 Type 1
	A307 Grade A or B
Nuts	ASTM A563 Grade DH
	A563 Grade A
Washers	ASTM F436 Type 1

39. 3.0 Execution

3.1 Pre-clean steelwork to produce an acceptable surface for quality hot dip galvanizing.

3.2 Application of Coating:

A. Galvanize steel members, fabrications, and assemblies by the hot dip process in accordance with ASTM A123.

B. Galvanize bolts, nuts, washers, and steel hardware components in accordance with ASTM A153.

C. Safeguard products against steel embrittlement in conformance with ASTM A143.

D. Galvanize reinforcing steel in accordance with ASTM A767.

E. Handle all articles to be galvanized in such a manner as to avoid any mechanical damage and minimize distortion.

F. Long tubular steel structures, which require double dipping to galvanize, shall be galvanized using a process in which the fluxing is a complete separate operation from the zinc dip (dry process).

3.3 Coating Requirements:

A. Coating Weight: Conform to paragraph 5.1 of ASTM A123, Table 1 of ASTM A767, or Table 1 of ASTM A153, as appropriate.

B. Surface Finish: Continuous, adherent, as smooth and evenly distributed as possible and free from any defects detrimental to the stated end use of the coated article.

C. Adhesion: Withstand normal handling consistent with nature and thickness of the coating and normal use of the article.

3.4 Testing:

A. Inspection and testing of hot dip galvanized coatings shall be done in accordance with ASTM A123, A767 or A153 as applicable to determine the thickness of the zinc coating on the metal surface.

3.5 Repair of Damaged Coating:

A. The maximum area to be repaired as defined in accordance with ASTM A123, Section 4.6, current edition.

B. Repair areas damaged during handling, transport or erection by one of the approved methods in accordance with ASTM A780 whenever damage exceeds 3/16 inch in width. Minimum thickness requirements for the repair are those described in ASTM A123, Section 4.6, current edition. Approved product is “Cold Galvanizing Compound” as manufactured by ZRC Corporation.

3.6 Delivery, Storage and Handling:

A. Store and protect products from damage to coating.

B. Load and store galvanized articles in accordance with acceptable industry standards.

6 Electrical

40. SECTION 6000 STATION EQUIPMENT

6.1.1 GENERAL

6.1.2 SCOPE

Except where material is specified to be supplied by the Owner, the Contractor shall furnish all material, labor, tools and equipment necessary to the station equipment as specified on the drawings and in the Owner’s Specifications.

6.1.3 CODES AND STANDARDS

Except as otherwise shown or specified, the Contractor shall comply with the provisions of the National Electrical Safety Codes, Owner and Industry specifications and standards, and the applicable codes, standards, and regulations set forth in M4-01-01 (Energy Storage Technical Documents) (the “BESS Spec”). The latest edition of the code or standard shall govern.

6.1.4 SUBMITTALS

The Contractor shall submit to Owner a manufacturer's specification and/or data sheet for all material the Contractor wishes to be considered as a substitute for what the Owner has specified. No substitutions are to be made without prior Owner approval.

6.1.5 MATERIALS

All materials furnished by Contractor shall comply with the specification and be approved by Owner. Non-metallic bollards shall be placed as appropriate around the perimeter of above-grade equipment (including the trenwa as needed), in particular in areas within or adjacent to driving lanes.

6.1.6 EXECUTION

6.1.7 COMMON REQUIREMENTS

Detailed information on type, rating and amount of equipment is shown on the drawings. At the time of installation, the Owner will furnish to Contractor one copy of manufacturers' drawings for assembling and installing major equipment.

Major equipment labeling shall be permanent and include type and location information.

Any equipment that is delivered to the site in crates shall be uncrated by Contractor. All equipment shall be completely assembled; including the installation of any accessories that may be shipped detached. All equipment shall be adjusted and lubricated in accordance with the manufacturers' instructions or as directed by Owner, so that all equipment is left in a satisfactory operating condition. Extreme care shall be exercised in handling porcelain or glass parts to avoid chipping or breakage.

Contractor shall perform all field drilling as required and attach any brackets, extensions or switch clip angles necessary for securely mounting the equipment. All field drilled holes shall be painted with ZRC (Zinc Rich Coating) as manufactured by Sealtube Owner of Wakefield, Massachusetts, or equivalent. Application shall be in accordance with the manufacturer's recommendations. Such field drilling and treatment shall not be a basis for additional compensation.

6.1.8 Power Transformers

The Contractor shall be responsible for assembling and preparation of the power transformer. Design, factory testing, assembly, field inspections, and field testing shall comply with the applicable specifications in M1-04-02 (General Transformer Specification).The power transformer shall be "Readied for Service" by Contractor under the supervision of the Owner's Representatives. Unless otherwise stated, the transformer shall be placed on the foundation with the centerlines of the tank installed directly above the centerlines of the foundation.

Assembling includes installing all bushings, arresters, radiators and auxiliary equipment. Contractor shall supply dry breathable air and purged through the transformer while work is being performed inside the transformer or any time any portion of the transformer is open. When all inside work has been completed, a pressure of 3 psi will be put on the transformer with dry breathable air to check for leaks. Unit must stand for 24 hours and maintain pressure. Some transformers come oil filled and ready for service.

The Owner will vacuum fill the transformer with oil if required.

6.1.9 Power Circuit Breakers

Contractor shall unload and place breakers in their final position on the foundation and install the bushings as required. The breaker shall be affixed to the foundation in the method specified on the drawings.

SF_6 type breakers shall be required in any instance where a circuit breaker is required and system voltage is equal to or above 69kV. For SF_6 type of breakers, the gas will be shipped in separate containers provided by the Owner. All gas containers, full, partially full, or empty are to be retained for proper inventory and returned to the Owner at the point of delivery. Contractor shall maintain a log of the amount of gas used for each piece of equipment, the gas container tracking number, equipment PGE number, date received, date used and date returned to Owner.

Contractor, please note that SF_6 gas is not toxic but care is advised.

Mounting provisions shall be formed-steel supports that mount the breaker to a foundation and provide height adjustment.

The low-voltage compartment of the circuit breakers shall contain the control

The stored energy mechanism shall drive a common shaft which operates all three phases and the auxiliary switches for breaker position contacts.

The control enclosure shall contain the relays, meters, and switches for the breakers.

The circuit breakers shall have provisions for mounting the protective relays in the control cabinet and remotely.

6.1.10 AIR BREAK DISCONNECT SWITCHES

The substation shall include the use of motor-operated and manually-operated disconnect switches. Feeder switches which are located between a feeder and a bus on the generation-side of a power transformer shall be worm gear or swing handle in type. Switches which separate a generator-side substation bus and a power transformer shall be group-operated and worm gear in type. Disconnect switches on the line-side bus of the power transformer shall be group-operated, and a disconnect switch which separates the interconnection line from the substation shall also be motor-operated.

The three-pole group-operated switches, including ground blades, when

supplied, shall be mounted as indicated on the drawings, with manual and control mechanisms to provide for operation from the ground. The switch mechanisms shall be adjusted for proper operation in accordance with manufacturer's instruction data.

All switches shall be suitable for outdoor use and shall be non-load break type.

All motor-operated switches shall include contacts and interlocks wired for protection and control with provisions for padlocking for personnel safety and maintenance. All switches shall have hard-wired interlocks and shall be designed and implemented to prevent operation in an undesired state.

6.1.11 CONTROL ENCLOSURE

The Contractor shall be responsible for assembling and preparation of the control Enclosure. The control house shall be placed on the foundation as recommended by the manufacturer.

The control enclosure shall be a new, prefabricated building. All electrical equipment shall be installed in the building prior to shipment.

The control enclosure shall be located within the fenced area of the project substation with a minimum of 20 feet of clearance on all sides.

The control enclosure shall be grounded and include HVAC.

The control enclosure shall contain a data concentrator and communications processor to collect project substation data signals for facility use.

The control enclosure shall include adequate space and clearance for all supplier-furnished SCADA system equipment.

Local user controls shall be included that are capable of overriding the controller if required for any reason. Local controls, including monitoring screens and keyboards, shall be placed in the control enclosure.

Assembling includes installing all racks, external wiring, cable tray, and auxiliary equipment.

6.1.12 METALCLAD SWITCHGEAR

The Contractor shall be responsible for assembling and preparation of the switchgear. The switchgear shall be placed on the foundation as recommended by the manufacturer.

Assembling includes installing all bushings, external wiring, bus connections, and auxiliary equipment.

6.1.13 POTENTIAL TRANSFORMERS

Contractor shall install the potential transformers, including voltage transformers and capacitor coupled voltage transformers on the specified structure as indicated on drawings.

The secondary junction boxes shall be assembled by the Contractor and mounted as shown on the drawings.

6.1.14 LIGHTNING ARRESTERS

The Contractor shall install the lightning arresters on the structure provided and as shown on the drawings.

High-side voltage surge arrestors shall meet the requirements of ANSI C62.11 for Station Class installation in a 60-Hertz outdoor installation. Surge arrestors shall be provided on the high-voltage bushings of the main step-up transformer.

34.5-kV surge arrestors shall meet the requirements of ANSI C62.11 for Station Class installation in a 60-Hertz outdoor installation. Surge arrestors shall be provided at the 34.5-kV breakers.

Equipment surge arrestors shall be station class, metal-oxide type surge arrestors for outdoor use and polymer housing. Surge arrestors shall be shatterproof.

6.1.15 SHUNT CAPACITORS

The Contractor shall assemble and install the capacitor rack elevating structures, in accordance with the manufacturer's instructions and on the foundations indicated on the drawings. The capacitor racks and current limiting reactors, if required, shall be installed on the elevating structures by the Contractor and as shown on the drawings. The Contractor, if specified, shall also be required to install the individual capacitor unit fuses.

Capacitor banks shall be sized and incorporated into the protect electrical design as necessary to comply with project requirements, including the Interconnection Agreement and FERC Order 827. Sizing of each device shall comply with the

Contractor-prepared Reactive Compensation Study as specified in M1-04-01 (General Electrical Study Requirements).

6.1.16 Junction Boxes and Capacitor Bank Control Cabinets

The Contractor is to assemble boxes, and cabinets, if assembly required, and mount them in the location on the structures as indicated on the drawings.

6.1.17 Current Transformers

The Contractor shall install the current transformers in the locations on the structures as indicated on the drawings. Contractor shall provide calculations to determine the possibility of AC saturation, DC saturation, and pregmanetization occurring at major equipment bushing current transformers and stand-alone current transformers.

6.1.18 Reactors

Reactor banks shall be sized and incorporated into the protect electrical design as necessary to comply with project requirements, including the Interconnection Agreement and FERC Order 827. Sizing of each device shall comply with the Contractor-prepared Reactive Compensation Study as specified in M1-04-01 (General Electrical Study Requirements).

Reactors will be delivered with coils, insulators and foundation fittings packed separately. The Contractor is to assemble the units per the manufacturer's mounting instructions and install on the structure as shown on drawings.

6.1.19 Meters

A revenue meter shall be installed at the project substation. The revenue meter shall be high accuracy and shall comply with the requirements as defined in Owner specifications, the interconnection agreement, and power purchase agreements.

Meters shall be installed on each medium-voltage collection system circuit feeder, although to the extent that the communications system can register production by feeder, a separate physical meter for each feeder is not required.

6.1.20 Relays

Protective relaying shall provide secure and selective isolation of equipment when necessary during faults, abnormal or hazardous operating conditions.

All relays shall be microprocessor-based and wired to a central communication processor with IRIG-B time stamping. The communication processor shall integrate all relaying.

Relay panels shall be located in the project substation control building and shall include all hard-wired and soft-wired protection and control interlocks.

Relay panels shall be installed in a new control room.

Protective relaying design and equipment selection shall be provided in accordance with applicable Requirements, including, but not limited to, the results of the Coordination study as defined in M1-04-01 (General Electrical Study Requirements), applicable standards and prudent electrical industry practices.

All protection device settings shall be provided for Owner’s review no later than 60 days prior to the system energization date.

Programming of devices shall be provided in electronic format straight from the device.

Owner will review and approve the final design prior to procurement of equipment.

The local utility shall require review and confirm line protection and signal exchange requirements. Owner shall facilitate such reviews.

Protection shall be provided for all breakers, bus, transformers, 34.5-kV lines, high-side lines, capacitors, and inductors.

The relaying schemes shall monitor and respond to over-currents, phase faults, ground faults, and other system abnormalities. Protection schemes to be utilized shall include, but not be limited to, line impedance/differential, bus differential, transformer differential, breaker failure, backup relaying, switch into fault, and sync check.

Annunciation and alarms shall be communicated to the Operator through an RTU that will signal loss of protection integrity including but not limited to: coil monitoring, loss of tripping power, gas pressure, relay failure, and other similar items.

High-side lines shall include primary and backup relaying.

Main step-up transformer protection shall include primary and backup relaying and monitor for oil and winding temperature.

Observe IEEE 1050 for protective instrument grounding.

6.1.21 Incidental Work

The Contractor shall provide and install the phase letter plates, high voltage warning signs, and the switch and equipment number plates as shown on the construction drawings or as directed by the Owner’s representative.

This work shall be considered incidental to the station equipment and the cost thereof shall be included in the contract prices for installation of station equipment.

6.1.22 Lightning Protection

Lightning protection shall be designed in accordance with IEEE 998.

Overhead shield wires installed on the take-off towers and lightning masts shall be provided for protection from direct lightning strikes. The shield system shall be adequately tied into the project substation ground grid.

Steel masts for direct stroke protection shall be round tapered seamless extruded or spun aluminum tubes. (a) The overall height of the masts above grade shall be determined from the direct stroke protection study, as defined by requirements set forth in M1-04-01 (General Electrical Study Requirements. (b) Masts shall have a single uniform taper from top to bottom. (c) Each mast shall be capped with a suitable finial. (d) Each mast shall be equipped with an internal vibration dampening device. (e) The design of masts shall have a safety factor of two (2) based on the allowable yield stress for the mast material in accordance with the latest ASCE specifications governing design of structures. (f) The horizontal deflection at the top of each free-standing mast shall be limited to L/20 of its height above foundation. (g) Each mast shall be installed on a concrete foundation with galvanized steel anchor bolts. Foundations, bolts, and welding shall be in accordance with the applicable structural requirements. (h) Each mast shall be provided with two grounding pads located 12 inches above the foundation.

41. SECTION 6010 BUS, CONNECTORS, and SHIELD WIRES

6.1.23 GENERAL

6.1.24 SCOPE

The work covered by this specification includes furnishing of all labor, equipment and materials (except supplied by Owner) required to install the tubular and wire bus, bus vibration damping, flexible steel shield wires, suspension and pedestal insulators, supports, fittings and connectors. Contractor shall also make connections to all equipment installed by Contractor.

6.1.25 CODES AND STANDARDS

Except as otherwise shown or specified, the Contractor shall comply with the provisions of the National Electrical Safety Codes, Owner and Industry specifications and standards, and the applicable codes, standards, and regulations set forth in the BESS Spec. The latest edition of the code or standard shall govern.

6.1.26 SUBMITTALS

The Contractor shall submit a manufacturer's specification and data sheet for all material the Contractor wishes to be considered as a substitute for what the Owner has specified. No substitutions are to be made without prior Owner approval.

6.1.27 MATERIALS

All material furnished by the Contractor shall comply with the specification and be approved by the Owner.

6.1.28 EXECUTION

3.1 Bus Erection. The bus, connectors and supports furnished by the Contractor shall be of the type and manufacture as shown on the drawings.

Connectors shall be of the proper size and design to assure permanent, secure, and low-resistance connections.

3.2 Aluminum Bus.

Design of the bus systems shall be in accordance with IEEE 605, at a minimum.

Loading and seismic performance shall be in accordance with the Project design and Project Site location. Such information is subject to verification by Contractor.

Rigid bus, at a minimum, shall be seamless, Schedule 40 tube made of 6063-T6 aluminum alloy fabricated per ASTM B241.

External bus dampers shall be installed on all horizontal bus.

Bus shall have one-quarter inch (1/4”) drain holes in all bus/fittings that could possibly trap water.

Station post insulators shall be of sufficient strength to support the rigid bus and shall be ANSI 70 gray color.

Bus support clamps for rigid bus shall be fixed or slip type as required to firmly support the bus but allow for temperature expansion and contraction.

The Contractor shall unpack, clean, and check all aluminum bus immediately upon receipt from the carrier. Bus delivered by the carrier with unsatisfactory finish shall be rejected. The Contractor shall remove all materials which might damage the bus finish and shall store the bus in such a manner that the finish will be protected. The Contractor shall be responsible for maintaining the finish on bus accepted from the carrier. Defective bus finish discovered after initial unpacking and inspection shall be the responsibility of the Contractor. All costs associated with the cleaning of minor black marks, abrasions, and scratches shall be included in the Contractor's bid. Any stored or erected bus found to have unsatisfactory finish shall be refinished or replaced by the Contractor at the option of the Project Field Manager. All expense for such refinishing or replacement shall be borne by the Contractor.

All bus shall be carefully handled and erected to provide a complete bus system without dents, abrasions, discolorations, or other structural or surface damage. Any bus so damaged shall be replaced by the Contractor at his expense.

Prior to the installation of fittings for the bus, conductors for vibration dampening, as required by the drawings, shall be installed within all horizontal buses for the full length of each bus.

Filler wires or rods shall be of 4043 aluminum alloy and of the proper diameter to suit the various applications. Installation of dampening wire shall be as shown in the drawings.

3.3 **Field Bends.** All field bends of bus shall be made with a hydraulic type bender which is acceptable to the Project Inspector. Each bend shall be smooth and uniform and shall retain the original inside bus diameter.

Bend radii shall be as indicated on the drawings. Each bend in 2 inch bus shall have a center line radius of at least 9-1/2 inches. Each bend in bus larger than 2 inches shall have a center line radius of at least five times the inside diameter of the bus.

3.4 **Alignment.** All bus components shall be aligned and supported prior to and during the welding operation. Support and alignment shall be as required to provide a finished bus arrangement with center lines of adjacent sections coincident. Bus shall be aligned for welding in such a manner that the welded bus remains essentially straight after removal of erection supports.

During splicing operations, each piece of bus shall be supported at not less than three points in approximately equal spans of 12 feet or less.

3.5 **Fittings.** The joint components to be welded shall be fitted to allow for expansion and contraction during welding without loss of alignment. The joint design shall be in accordance with manufacturers' recommendations. Connections shall be positioned and located to prevent the retention of water or drainage from copper or copper alloys to aluminum surfaces. The Contractor shall locate bus splices in locations that will not impose a moment on the splice hence damaging the splice. The location of maximum bending moment usually exists at the midspan and at the bus support. The Contractor shall not locate a bus splice within a distance of 10 percent of the total span length from the bus midspan or from the bus support. Only one bus splice is allowed within one bus span.

Fittings shall be of the proper size and design to assure permanent, secure, and low-resistance connections.

All dead-end fittings, terminals, splices, and other similar items for ACSR and other types of stranded aluminum conductor shall be tubular compression type fittings. In no case shall any type of stranded aluminum conductors be used with bolted or clamp-type fittings, except for through-type connections to surge arresters on transformers.

At least five percent (5%) extra dead-end body filler plugs for each type used shall be provided. Fittings shall develop the full strength of the conductor and shall be capable of carrying the full current capacity of the conductor.

Fittings for shield wire dead ends, splices, and taps shall conform to the following:

- Shield wire dead-end fittings shall be compression type with bolted jumper connection. Shield wire insulators shall be located as indicated.
- Compression sleeves for shield wire tension splices shall be used which will develop at least ninety percent (90%) of shield wire strength.

3.6 Weep Holes. Weep holes shall be provided as required. Weep holes shall be ¼" cleaned and deburred, at a minimum, one weep hole will be located approximately mid span for all horizontal bus spans. Weep holes shall be circled with a black marker for easy verification.

3.7 **Wire** Bus Fittings. Wire bus fittings for aluminum conductors shall be compression type only. Wire bus fitting for copper conductors shall be clamp type with high-strength nonferrous bolts and spring washers supplied with the fittings. Washers shall have a minimum compression rating of 4,000 pounds. Bolt lengths shall be sized to provide minimal projection beyond hex nut to prevent excessive noise due to corona, but entire hex nut must be engaged. Contractor shall leave all bolts thoroughly tightened. Compression connections shall be installed as shown on the drawings. Compression tools used shall be of the type and size that is recommended by the connector manufacturer or as approved by Owner. For all terminal connections involving the bolting together of an aluminum terminal connector with a bronze connector, all surfaces shall be thoroughly cleaned and an oxide-breaking, corrosion-inhibiting compound shall be applied to the contact surfaces before being bolted together. The Contractor shall leave all bolts thoroughly tight. For copper to aluminum connections, stainless steel bolts shall be used for copper to aluminum bar or rod connections and faced or sleeved aluminum connectors shall be used for cable connections. All connections between stranded aluminum or ACSR-type conductors and equipment stud terminals shall be made with a stud-to-pad type stud connector and a compression-type cable-to-pad type conductor termination.

3.8 Cable Jumpers. Cable jumpers and vertical cable taps shall be installed as specified on the drawings and be of such length and form as to maintain maximum clearance from surrounding objects and to give assurance that such contour will be stable.

3.9 Cleaning. Immediately prior to welding, each surface to be joined by the weld shall be thoroughly cleaned. Greases, oils, waxes, etc., shall be removed by standard degreasing solutions as recommended by the manufacturer. Oxides shall be removed from the areas to be welded by vigorous scrubbing of the surfaces with stainless steel wire brushes.

3.10 Welding. Welding processes and methods shall be subject to code qualification and acceptance by the Engineer. Only the following welding methods will be permitted for joining bus sections and fittings:

- Gas metal arc welding.
- Gas tungsten arc welding.

Shielding gas for each process shall be welding grade argon when welding material is less than 3/4 inch thick. A combination of helium and argon shall be used for each process when the welding material is 3/4 inch thick and greater.

Welding energy and filler metal requirements shall be as recommended by AWS D10.7-86, "Recommended Practices for Gas Shielded Arc Welding of Aluminum and Aluminum Alloy Pipe." The following from AWS D10.7 shall apply:

3.11 Welding Qualifications. The Contractor shall prepare written welding procedure specifications. The procedure shall be qualified as defined below. Welding procedure specifications, procedure qualification reports, and welder qualification reports shall be submitted to the Owner and Engineer for review. Welding shall not begin until the Owner's and Engineer's review is complete.

All procedure qualification testing and welder qualification testing shall be in accordance with the methods defined in AWS D10.9-80, "Specification for Qualification of Welding Procedures and Welders for Piping and Tubing."

Testing shall be conducted to the requirements of AR-1 qualification level under the following conditions:

Materials	P-Number 23, aluminum base alloys
Weld	Groove
Position	6G

All qualification testing shall be performed by an acceptable independent testing laboratory. Report formats shall be similar to the examples in AWS D10.9-80 for the following:

Typical Welding Procedure Specification (WPS).

Typical Contractor's Procedure Qualification Test Record (PQR). Typical Contractor's Welder

Qualification Tests Record.

All costs for testing, including material costs, shall be paid by the Contractor.

Welders, after qualification, shall not be replaced on this welding duty unless such action is acceptable to the Project Field Manager.

3.12 **Handling of Bus.** The tubular bus, wire bus and bus fittings, including corona shields or grading rings, shall be handled in such a manner that insures no surface damage will occur. The outer surfaces of all installed conductors and fittings shall remain smooth and free from scratches, nicks, dents or any other surface damage. Methods of handling and transportation of all material will be subject to the approval of Owner.

3.13 **Repair of Damaged Bus & Fittings.** All damaged material, at the cost of the Contractor, shall be repaired or replaced to full satisfaction of Owner. Damage is considered to include all surface defects, which can be felt by the fingers as well as all visible defects. Minor damage to the tubular bus, the bus fittings and the corona shields or grading rings may be repaired by filing and smoothing out the damaged area with a fine emery cloth. Damaged areas will be considered restored when no surface defect can be felt on the damaged piece. Tubular bus that is severely damaged shall be repaired. The damaged portion shall be cut out and replaced with a coupling or as directed by Owner. At the cost of the Contractor, severely damaged fittings and corona or grading rings shall be replaced.

All tubular bus repaired and items replaced because of damage after delivery to the Contractor shall be the responsibility of the Contractor. All bus, repair couplings and other repair or replacement items are to be furnished by the Contractor.

3.14 Handling of Cable Conductor. The cable conductor shall be handled in such a manner that no surface or internal damage will occur. The outer surface of all installed conductor shall remain as smooth and free from scratches, nicks, dents or other surface damage as it does on reels at the time of delivery to the Contractor. Contractor shall reinforce the reels or if required, rewind on new reels to permit handling without damaging the conductor. Methods of handling and transportation of all material will be subject to the approval of Owner.

3.15 Installation of Insulators. The Contractor shall furnish insulators as specified on the Bill of Materials, unless otherwise specified. All suspension and pedestal type of insulators shall be located and installed as shown on the drawings. Any surplus material shall be properly identified, tagged and returned to the designated Owner storeroom.

3.16 Bus Supports. Bus supports of the type and size specified on the drawings or Bill of Materials list shall be supplied by the Contractor and installed as indicated on the drawings.

3.17 Connections. The Contractor shall make all cable and bus connections to the installed equipment as directed and as specified on the drawings. Any changes as to type of connector, bus or cable size and type, method of connecting, or any other deviations from what is specified on the drawings shall not be made without approval from the Owner.

3.18 Shield Wire. If required the Contractor will supply steel shield wire unless otherwise specified. The Contractor is to install the shield wire in the locations and as specified in the drawings.

42. SECTION 6040 CONTROL AND POWER CABLE

6.1.29 GENERAL

6.1.30 SCOPE

Insulated cable, conductors, and conductor accessories shall be furnished and installed in accordance with the requirements of this section of these specifications. Insulated cable, conductors, and conductor accessories shall be furnished in quantities sufficient for a complete installation as indicated in the circuit lists, on the drawings, and in these specifications. Power conductor size and ampacity shall be coordinated with circuit protection devices. Conductor size shall be determined for 125% of connected load at the design basis maximum outdoor ambient temperature. Within the Project Substation, below-grade power cable conductor size shall be determined in accordance with the methods in IEEE 835.

All Project Substation control and instrument cables shall be shielded.

The cable furnished shall be flame retardant construction in accordance with the applicable ICEA standards and suitable for wet or dry locations.

All cable shall have surface printing showing manufacture’s name, insulation type, jacket type, conductor size, conductor type, voltage rating, and numbered footage markers.

Cable reels shall be stored and handled in a manner which will prevent physical damage to the cable. Cable reels shall be stored on a hard surface to prevent contact between cable insulation and earth due to sinking of the reel.

Installation shall be defined to include placement, terminating conductors, coiling and taping of spare conductors, identification, testing, and verification of each circuit, cable, and conductor. Installation of cable in existing trays or cable trench shall also include removal and replacement of existing cable tray or cable trench covers.

Terminating a conductor shall include installing cable termination kits for shielded cable, attaching the conductor at its designated location and insulating the entire connection where specified or required by the application.

6.1.31 CODES AND STANDARDS

Contractor shall comply with the appropriate provisions of the National Electric Safety Codes, PGE standard S-144-10, Industry specifications and standards except as otherwise specified or shown and the applicable codes, standards, and regulations set forth in the BESS Spec. The latest edition of the code or standard shall govern.

6.1.32 SUBMITTALS

The Contractor shall submit to PGE Substation Engineering, a manufacturer's specification and/or data sheet for all material the Contractor wishes to be considered as a substitute for what the Company has specified. No substitutions are to be made without Owner’s approval.

6.1.33 MATERIALS

The cable furnished shall conform to the Cable Specification Sheet(s) included at the end of this section.

The term "Type" used in the circuit list, on the drawings, and in these specifications refers to the letter identification indicated on each Cable Specification Sheet.

Insulated cable, conductors, and conductor accessories shall be furnished and installed in accordance with the requirements of these specifications and the recommendations given in IEEE 525. Insulated cable, conductors, and conductor accessories shall be furnished in quantities sufficient for a complete installation as indicated in these Specifications.

2.1 **Coaxial Cable.** Coaxial cable (when specified) used for connection between carrier cabinets and line tuning units shall be 52 ohm RG-8A/U coaxial cable. The cable shall have an 8 mil thick aluminum flat tape water block and an overall chlorinated polyethylene jacket. The cable shall be Belden Catalog No. 9251-A282-BV. This cable is a special run item.

2.2 **Color Coding.** The color code used for Type F, multiconductor, shielded or unshielded control cable shall be in accordance with Tables E-2 of ICEA S-73- 532 as indicated on the Specification and Data Sheet(s). All of the wiring diagrams being prepared by the Engineer are based on the color code specified on the

Specification and Data Sheet(s). The Tables E-2 color codes are as follows:

Conducto	Method 1 Table E-2
1	Black
2	Red
3	Blue
4	Orange
5	Yellow
6	Brown
7	Red-Black
8	Blue-Black
9	Orange-Black
10	Yellow-Black
11	Brown-Black
12	Black-Red
13	Blue-Red
Conducto	**Method 1 Table E-2**
14	Orange-Red
15	Yellow-Red

2.3 **Conductor Accessories.** All conductor accessories including connectors, terminations, insulating materials, support grips, markers, and cable ties shall be furnished and installed by Contractor.
Supplier's installation instructions shall be provided by Contractor for cable accessories. These instructions shall be in the possession of the craftsmen while installing the accessories and shall be available to the Project Field Manager for reference.

2.4 **Terminal Connectors for Conductors 8 AWG and Larger.** Terminal connectors for conductors 8 AWG and larger shall be pressure or bolted clamp type, Burndy Qiklug, Varilug, or acceptable equal; or compression type, Burndy Type YAV or YA (long barrel), Panduit Type LCA or LCC, or acceptable equal. Acceptable connectors included with Owner-furnished equipment may be used.

2.5 **Terminal Connectors for Conductors Smaller than 8 AWG.** Terminal connectors for conductors smaller than 8 AWG shall be compression type connectors properly sized for the conductor and the terminal. The connectors shall be constructed of fine grade high conductivity copper in accordance with QQ-C-576 and shall be tin plated in accordance with MIL-T-I0727. The interior surface of the connector wire barrel shall be serrated, and the exterior surface of the connector wire barrel shall be provided with crimp guides.

Noninsulated terminal connectors shall be provided on conductors terminated on devices equipped with individual fitted covers, such as General Electric Type SB-I control switches and General Electric Type HEA lockout relays. Non-insulated ring type terminal connectors shall be used on all current and potential transformer circuits. All other terminal connectors for conductors smaller than 8 AWG shall be non-insulated ring type or preinsulated spade type.

Ring type connectors shall be manufactured by AMP, 3M, Panduit, or acceptable equal. Spade type connectors shall be AMP slotted spring spade, 3M Scotchlok Series 6I snap spade, or Panduit locking fork terminal connectors.

2.6 **Crimping Tools.** Use only ratchet type crimping tools a for all lugs and splices. Crimping tools used to secure conductors in compression type connectors or terminal lugs shall be those made for that purpose and for the conductor sizes involved. The crimping tools shall accurately crimp the connector barrel and shall accurately crimp the conductor insulation support sleeve where provided. Crimping tools shall be provided with guides to position connectors in the tool, shall be provided with stops to prevent overcrimping, and shall be of a type which prevents the tools from opening until the crimp action is completed. Crimping tools shall be a product of the connector manufacturer or shall be as recommended by the connector manufacturer and acceptable to the Engineer for use with the connectors.

The Contractor shall establish and maintain a tool certification program to ensure that crimping tools are kept in accurate operating condition.

2.7 **600 Volt Cable Insulating Materials**. Insulating materials for terminal connectors or compression type connectors shall consist of varnished cambric tape, rubber tape, and vinyl tape. Taping materials shall be as listed below or acceptable equal:

- Varnished Cambric Tape--3M Company Irvington 2520.
- Rubber Tape--3M Company Scotch 130C.
- Vinyl Tape--3M Company Scotch 33+.

2.8 **Support Grips.** Cable support grips shall be either split or closed woven wire type as manufactured by The Kellems Division, Harvey Hubbell Incorporated, Stonington, Connecticut.

2.9 **Wire and Cable Markers.** Markers for wire and cable circuits shall be of an opaque nylon material arranged to include a marker board, nonreleasing holding device, and cable fastening tail. The marker board shall not be less than 3/4 inch wide, 2-1/2 inches long, and 15 mils thick and shall be Panduit Corp. Part No. MP250 marker plates or acceptable equal. One side shall be roughened to hold black nylon marking ink from a fine tip pen similar to Thomas & Betts Company "TY-RAP" marking pen, Catalog No. WTI63M-I, or Panduit Corp. Part No. PFX-0 marking pen. Identification shall be permanent and waterproof. The holding device shall be designed to allow the fastening tail to pass around the cable through the holding device and prevent the removal of the tail without cutting it loose from the marker.

2.10 **Cable Ties.** Lacing materials for field installed cable shall be nonreleasing weather-resistant black nylon ties manufactured by Thomas & Betts Company, Elizabeth, New Jersey; Panduit Corp., Tinley Park, Illinois; 3M Company; or acceptable equal.

2.11 **Cable Shield Bonding Connectors.** Cable shield bonding connectors for use with shielded power, control, and instrumentation cable shall be Scotchlock 4460, manufactured by the 3M Company; Nicopress Shield Connector B-2974, manufactured by National Telephone Supply Company; Surgegard Shield Bond Connector, manufactured by Brand-Rex Company; or acceptable equal.

Cable shield bonding connectors shall be installed on one end of each shielded power, control, and instrumentation cable listed in the circuit lists.

Concentric neutral of all 15 KV-34 KV power cable, all concentric neutral will be long enough to reach the station ground grid/bus without being spliced

3.1 Execution

Conductor installation shall be in accordance with the cable manufacturer's recommendations and the articles which follow.

3.2 **Cable Placement.** All cable described in the circuit lists shall be routed as indicated therein. Routing of other cable shall be as indicated on the drawings. Cable shall not be handled when the cable temperature is below the minimum temperature recommended by the manufacturer. If cable heating is required prior to placement, the cable shall be stored in a heated building in accordance with the manufacturer's recommendations for at least 24 hours.

Cable shall be placed the same day it is removed from heated storage.

If at any time during the progress of the work the Contractor finds raceways which appear inadequate to accommodate the assigned cable, he shall notify the Project Field Manager at once and shall discontinue any further work on the questionable raceway until advised by the Project Field Manager as to how he shall proceed.

Immediately prior to the placement of each cable or cable group, the raceway route to be followed shall be inspected and ascertained to be complete in installation and free of all materials detrimental to the cable or its placement. All cable assigned to a particular duct or conduit shall be grouped and pulled in simultaneously using cable grips and acceptable lubricants.

All cable shall be carefully checked both as to size and length before being pulled into conduits or ducts. Cable pulled into the wrong conduit or duct or cut too short to rack, train, and splice as specified herein shall be removed and replaced by and at the expense of the Contractor. Cable removed from one conduit or duct shall not be pulled into another conduit or duct.

3.3 **Cable in Trays**. All cable shall be carefully laid in or pulled through the tray system so that neither the cable nor the trays are damaged. Cable may be laid along the side of the tray system during placement provided it is protected from dirt, water, oil, or other detrimental materials and from mechanical injury. Cable shall be cut sufficiently long to conform to the contour of the trays, with particular attention paid to vertical inside bends. All excessive slack shall be removed from the cable so that it lies parallel to the sides of the trays. Multiple single conductor cable which constitutes a single power circuit shall be grouped together to minimize magnetic influence on other cable in the area.

The cable shall be tied to the trays with nylon ties at l0 foot intervals to hold it in place. Cable clamps designed for holding the cable inside the trays shall be installed at all vertical bends.

3.4 **Cable in Vaults**. Cable shall be supported at all times without short bends or excessive sags and shall not be permitted to lie on the manhole floor. Cable ends must not be submerged. Cable racks or trays shall be provided for permanent support. Temporary support required during placement shall be with rope slings, timbers, or alternate method acceptable to the Project Field Manager.

3.5 **Cable Pulling**. Fishing and pulling shall be done with flexible round metal tape, CO_2 propelled polyethylene cord, nylon rope, or manila rope.

Unless specified otherwise or acceptable to the Project Field Manager, cable shall not be pulled in a single pull through two sections of Engineer-designed raceway connected by a manhole or pull box. Cable shall be pulled out at each manhole and pull box to the length required for termination. Prior to re- pulling of the pulled out cable, the cable shall be thoroughly inspected, cleaned, and relubricated. Damaged cable shall be removed and replaced by and at the expense of the Contractor.

Cable may be pulled in a single pull through two sections of Engineer- designed raceway connected by a manhole or pull box only if it can be determined by calculation to the satisfaction of the Project Field Manager, that the pulling tension will not exceed the maximum tension allowed by the cable manufacturer.

3.6 **Cable Grips**. Factory installed pulling eyes shall be used for pulling cable where they are available. Woven wire cable grips shall be used to pull all single conductor cable 2/0 AWG and larger, where pulling eyes are not available, and all multi-conductor cable. Pulling loops shall be used to pull single conductor cable smaller than 2/0 AWG. All sharp points and edges on the hardware attaching the pulling rope to the cable shall be taped to prevent snagging or damaging the raceway. When a cable grip or pulling eye is used for pulling, the area of the cable covered by the grip or seal plus 6 inches shall be cut off and discarded when the pull is completed. When pulling loops are used, the entire loop shall be cut off and discarded when the pull is completed.

As soon as the cable is pulled into place, the pulling eyes, cable grips, or pulling loops shall be removed and any cable which was sealed shall be resealed.

3.7 **Swivels**. A reliable nonfreezing type of swivel, or swivel connection, shall be inserted between the pulling rope and the cable pulling eye, grip, or loop to prevent twisting under strain.

3.8 **Feeding Tubes**. A 4 inch or larger flexible feeding tube, with a removable nozzle sized to fit the ducts, shall be used in pulling all underground cable. The feeding tube shall be long enough to extend from the duct entrance to the outside of the manhole and shall be so arranged that it will be impossible for the cable to drag across the edge of the manhole ring or any other damaging surface. The bending radius of the tube shall not be less than the minimum bending radius of the cable specified in this section under the article titled Cable Bends.

3.9 **Pulling Lubricants**. Only lubricants recommended by the cable manufacturer and acceptable to the Project Field Manager shall be used. Lubricants shall be applied liberally and continuously during the pull.

3.10 **Inspection**. The outside of each cable reel shall be carefully inspected and protruding nails, fastenings, or other objects which might damage the cable shall be removed. A thorough visual inspection for flaws, breaks, or abrasions in the cable sheath shall be made as the cable leaves the reel, and the pulling speed shall be slow enough to permit this inspection. Damage to the sheath or finish of the cable shall be sufficient cause for rejecting the cable. Cable damaged in any way during installation shall be replaced by and at the expense of the Contractor.

3.11 **Pulling Tension**. The pulling tension of any cable shall not exceed the maximum tension recommended by the cable manufacturer. Pulling mechanisms of both the manual and power types used by the Contractor shall have the rated capacity in tons clearly marked on the mechanism. Whenever the capacity of the pulling mechanism exceeds the recommended pulling tension of the cable as given by the cable manufacturer, a dynamometer shall be used to show the tension on the cable and the indicator shall be constantly watched. If any excessive strain develops, the pulling operation shall be stopped at once and the difficulty determined and corrected.

3.12 **Sidewall Pressure**. To avoid insulation damage from excessive sidewall pressure at bends, the pulling tension in pounds at a bend shall not exceed 300 times the radius of the bend in feet.

3.13 **Cable Bends**. Tape shielded, flat tape armored, and wire armored cable shall not be bent to a radius of less than 12 times the overall cable diameter. Nonshielded conductors shall not be bent to a radius of less than eight times the cable diameter.

3.14 **Supports**. All cable supports and securing devices shall have bearing surfaces located parallel to the surfaces of the cable sheath and shall be installed to provide adequate support without deformation of the cable jackets or insulation. Adequate cable end lengths shall be provided and properly placed in junction boxes and manholes to avoid longitudinal strains and distorting pressures on the cable at conduit bushings and duct end bells.

Final inspection shall be made after all cable is in place and, where supports or raceway fittings deform the cable jacket, additional supports shall be provided as directed by the Project Field Manager. Additional cable protection such as a wrapping of light rubber belting, friction tape, or similar material shall be provided where required.

Cable in vertical runs shall be supported by woven wire grips in accordance with the NEC requirements, except that the distance between supports shall conform to the following:

Conductor Size	Vertical Cable Support Spacing	
	Aluminum Conductor	Copper Conductor
1/0 AWG and smaller	100 feet	100 feet
2/0 AWG thru 500 Mcm	120 feet	50 feet
Larger than 500 Mcm	85 feet	35 feet

3.15 **Cable Racks**. Where cable trays are not specified in man-holes, cable racks shall be furnished and installed according to the drawings and as required to provide the proper cable support. Cable racks shall be installed on spacings of not greater than 36 inches and shall be bolt secured to permanent wall surfaces with self-drilling anchors or continuous slot concrete inserts.

3.16 **Spare Conductors.** All spare conductors of a multi-conductor cable shall be left at their maximum lengths for possible replacement of any other conductors in the cable. Each spare conductor shall be neatly coiled and then taped to the conductors being used.

3.17 **Lacing**. Nylon ties shall be used to neatly lace together conductors entering switchboards and similar locations after the conductors have emerged from their supporting raceway and before they are attached to terminals.

3.18 **Cable Identification**. The Contractor shall identify the ends of all circuits listed in the circuit lists. Use PGE standard S-144-10 and its addendum.
Each marker shall bear the number of the circuit according to the circuit lists and drawings.

At terminations, the Contractor shall identify each conductor of power circuits, each multi-conductor cable, and each conductor of circuits consisting of multiple single conductors where the conductors are not otherwise identified. Markers shall be attached where the first individual conductor is routed away from the assembly. Each phase of multiphase power circuits shall be individually identified.

One end of each marker board shall remain free of the fastening tail, and the entire marker shall be so attached that it is readily visible for circuit identification.

3.19 **Moisture Seals**. Each cable with an aluminum conductor shall be kept sealed except when termination and splicing work is being performed.
The ends of all cables shall be sealed with heat shrinkable caps. Cap sizes shall be as recommended by the cap manufacturer for the cable OD and insulation. Caps shall contain sufficient adhesive that shrinkage of the cap during application results in formation of a positive water-tight seal capable of withstanding complete immersion or total exposure without permitting the entrance of moisture. Heat shrinkable caps shall be "Thermofit" as manufactured by Raychem Corporation or acceptable equal.

Before and after pulling, the leading end seal of each length of cable shall be examined and repaired if necessary. All cut cable ends shall be promptly sealed after cutting except those to be spliced or terminated immediately.

3.20 **Splices.** No splices shall be made in conductors for instrument circuits or control circuits. Shields may be spliced where necessary to permit connection to the station ground.
Power cable circuits may be spliced only by methods and at locations acceptable to the Project Field Manager.

3.21 **Terminations.** Cable shall be terminated in accordance with the following requirements:
Train cable in place and cut squarely to required length. Avoid sharp bends.

Remove necessary amount of cable jacket and insulation without damage to the conductor.

Install terminals or terminal connectors as required, ensuring a firm metal-to- metal contact.

Insulate each connection of cable to an insulated conductor (whether cable, bus, or equipment bushing). The insulation shall cover all exposed surfaces of the conductors; the insulation voltage level of the completed termination shall be not less than the insulation voltage level of the connected conductors.

3.22 **Insulation of 600 Volt Cable Connections**. Where connections of cable rated 600 volts or less require insulation, all exposed conductor and connector surfaces shall be covered with tape in accordance with the following:
One half-lapped layer of varnished cambric tape.

A minimum of three half-lapped layers of rubber tape, elongated not more than 20 percent, applied over the varnished cambric tape.

A minimum of three half-lapped layers of vinyl tape applied over the rubber tape. The vinyl tape shall extend a minimum of two cable diameters over the cable jacket and a similar distance over the insulation of the conductor to which the cable is connected.

6.1.34 TESTS AFTER PLACEMENT

All insulated conductors shall be electrically tested after placement.

All circuits, including lighting circuits, shall be tested with the circuit complete except for connections to equipment. All splices, stress cones on shielded cable, and terminal connector attachments shall be complete prior to testing.

In addition to the tests performed after cable placement is complete, continuity tests and insulation tests shall be performed on all supervisory and communication cable before and after each splice is made.

Any circuit failing to test satisfactorily shall be replaced or repaired and then retested.

All equipment and labor required for testing shall be furnished by the Contractor.

4.1 Continuity and Identification Tests. All insulated conductors shall be tested for continuity and conductor identification.

- **Continuity tests**. Continuity tests shall include all tests necessary to confirm that each conductor is continuous throughout its entire length.
- **Identification tests**. Identification tests shall include all tests necessary to confirm that the conductor being investigated originates and terminates at the locations designated in the circuit lists or indicated on the drawings.
- Contractor shall supply Owner with yellow-lined schematic and wiring diagrams verify circuit testing and verification.

4.2 Insulation Tests. Resistance from ground provided by the insulation on all field installed insulated conductors shall be measured.

- **Cable rated 600 volts and below**. All insulated conductors except supervisory and communication cable, rated 600 volts and below shall be tested with a 1000 volt megger or an equivalent testing device. Insulation resistance measurements shall be made between each conductor and ground and between each conductor and all other conductors of the same circuit. Minimum acceptable resistance values shall be approximately 100 megohms.
- **Supervisory and communication cable**. All insulated conductors of supervisory and communication cable shall be tested with a 500 volt megger or an equivalent testing device. Insulation resistance measurements shall be made between each conductor and the cable shielding tape and between the two conductors in each pair. Minimum acceptable resistance values shall be 2 megohms.

6.1.35 FIBER-OPTIC DUCT CABLE

Fiber-optic duct cable (FODC) and accessories shall be furnished in accordance with the requirements of this section of these specifications. FODC cable and accessories shall be furnished in quantities sufficient for a complete installation as indicated in these specifications.

Contractor will provide the fiber optic cable per the cable schedule and lists of materials. Fiber requirements for the communications rack will be provided by PGE. DTS fiber that will be pulled with the 34.5kV power cable will be supplied by PGE.

Cable reels shall be stored and handled in a manner which will prevent physical damage to the cable. Cable reels shall be stored on a hard surface to prevent contact between cable insulation and earth due to sinking of the reel. Impact damage between reels shall be prevented by aligning reels flange to flange or by using guards across flanges.

Cable ends, whether exposed or concealed, shall be sealed to prevent moisture penetration. Cap sizes shall be as recommended by the cap manufacturer for the cable. Caps shall contain sufficient adhesive so that the cap provides a watertight seal capable of withstanding complete immersion or totally exposed storage over a period of several months without permitting the entrance of moisture.

5.1 **Attenuation Measurements.** Attenuation measurements shall be performed on all fibers of each reel of FODC at both 1310 nm and 1550 nm. An optical time domain reflectometer (OTDR) shall be used for all attenuation measurements. The measurements shall be made from both directions and the results shall be averaged. The optical loss measured at any stage of manufacturing shall not exceed the allowable attenuation as specified in the Cable Specification Sheet included at the end of this section. The attenuation specified is the maximum allowable attenuation for each reel of FODC, not the average attenuation of all reels for each path. Contractor shall provide fiber link loss calculations which verifies that each individual fiber segment's attenuation as determined by attenuation per splice, connector, and fiber length does not exceed maximum attenuation requirements as defined by Owner. Contractor shall be responsible for designing and installing fiber such that it does not exceed the maximum attenuation as determined by fiber link loss calculations.

5.2 **Innerduct.** All fiber shall be installed in innerduct. Innerducts shall be high density polyvinylchloride corrugated induct as manufactured by Phillips Drisco Pipe, Carton, Endot or Dura-Line. The innerduct shall be 1 inch or 1- 1/4 inch inside diameter, or as indicated on the drawings, and shall contain 1/4 inch polyproplene stranded rope for use in pulling the cable or other pulling line. Interduct shall be orange and labeled "Fiber-Optic" at 10 feet intervals.

43. SECTION 6050 PRE-CAST CABLE TRENCH & VAULTS

6.1.36 GENERAL

6.1.37 SCOPE

The work covered by this specification includes furnishing of all labor, equipment and materials required for the purchase and installation of pre- cast cable trenches and vault, and fiberglass covers as shown on the drawings and specified herein.

6.1.38 MATERIALS

2.1 Contractor Supplied Materials

A. Contractor shall furnish a trench and vault system consisting of precast concrete support brackets, sidewalls and removable fiberglass covers to form a completely enclosed trench, except with an open earth bottom.

B. The manufacturers shall be specified on the drawings or bill of material.

C. The trench system (with the exception of the road rated trench sections) shall be designed to support at least 200-psf live load.

D. Road rated trench sections and vaults identified on the drawings shall be designed to carry HS-20 (32,000#) axle loading. The clear interior cross section shall be the same as the connecting trench.

E. Typical trench width, depth and cross sections are shown on the drawings.

F. Typical vault width, depth and cross sections are shown on the drawings.

G. Backfill used for trench installation shall be road rock as specified in Road

Finish Rock section, unless noted otherwise.

H. Contractor shall supply sand for cable bedding.

I. Concrete materials used in fabrication of the trench components shall be in accordance with ACI 318. Reinforcing shall be in accordance with ASTM 615 grade 60. Miscellaneous steel, bars, and plate shall be in accordance with ASTM A36.

J. Concrete mixing and placement shall be in accordance with ACI 304. Concrete strength shall be designed for durability, have a minimum compressive strength of 4,000 psi and contain 6% (plus or minus 1%) entrained air.

K. Reinforcement will be sized and located by the manufacturer. Placement shall be in accordance with ACI 315 and ACI 318.

L. Precast concrete sections shall be inspected when delivered to the site. Cracked or otherwise visibly defective units shall be rejected and removed from the site.

6.1.39 EXECUTION

Precast concrete sections shall be lifted by suitable lifting devices at points provided by the precast supplier and installed in accordance with the precast supplier's recommendations. Joints between precast sections shall be sealed with a rubber gasket.

Where masonry is required to close the conduit openings in the precast sections, mortar shall be used within 40 minutes after mixing. Mortar that begins to set shall be discarded. Outside surfaces of brick and block masonry shall be plastered with mortar.

Contractor shall install the trench system and vaults at a depth ensure that all conduits and trench interfacing with the vault are at the appropriate depth.

The fiberglass lid shall be easily removed and replaced

6.1.40 TRENCH SYSTEM

Contractor shall install the trench components and covers in accordance with the manufactures instructions and drawings.

Contractor shall install a 4" deep layer of loose bedding of sand the entire length of the trench including road crossings.

After cables have been laid all road crossing and pedestrian covers shall be in place.

All trench road crossings within the station must remain open to traffic. Removal of covers is allowed but they must be returned at the end of each workday unless provision is made for an alternate route or temporary road plates are used.

Throughout construction all open trenches shall be marked with non- conductive safety tape when not actively worked.

Two bare copper ground conductors, equal in size to the ground grid conductors, shall be routed with each trench route as indicated on the drawings. The trench ground conductors shall be connected to the substation ground grid.

6.1.41 VAULTS

Contractor shall install the vault components and covers in accordance with the manufacturer's instructions and drawings.

44. SECTION 6060 CONDUITS AND DUCT BANKS

6.1.42 GENERAL

6.1.43 SCOPE

The work covered by this specification includes the furnishing of all labor, tools, and equipment necessary to install the control/power cable conduit system in the substation / switchyard as shown on the drawings and as specified herein.

6.1.44 CODES AND STANDARDS

Except as otherwise shown or specified, the Contractor shall comply with the provisions of the National Electrical Safety Codes, Owner and Industry specifications and standards, and the applicable codes, standards, and regulations set forth in the BESS Spec. The latest edition of the code or standard shall govern.

AISC's "Manual of Steel Construction"

ANSI C62.11

NESC Section 32: Underground Conduit Systems

IEEE Standard 525 - IEEE guide for the Design and Installation of Cable Systems in Substations

IEEE Standard 693 - Recommended Practice for Seismic Design of Substations

IEEE Standard 835 - Standard Power Cable Ampacity Tables

National Electric Code

NEMA Standard Publication #OS 1 Sheet Steel Outlet Boxes, Device Boxes, Covers, and Box Supports

NEMA Standard Publication #OS 2 Nonmetallic Outlet Boxes, Device Boxes, Covers, and Box Supports

6.1.45 MATERIALS

Electrical conduit and associated materials shall conform with the requirements of the articles which follow.

2.1 **Rigid Aluminum Conduit**. Aluminum conduit and couplings shall be rigid type conforming to ANSI C80.5 and shall bear the Underwriters' Laboratories label.

2.2 **Rigid Steel Conduit**. Steel conduit, couplings, and elbows shall be hot-dip galvanized rigid mild steel in accordance with ANSI C80.I and UL 6. The conduit interior and exterior surfaces shall have a continuous zinc coating with a transparent organic polymer topcoat. The transparent organic polymer topcoat shall be chromate free. Rigid steel conduit shall be as manufactured by Triangle PWC, Incorporated or acceptable equal.

2.3 **Plastic Conduit**. Plastic conduit shall be Schedule 40, high impact, polyvinyl chloride and shall be used with plastic conduit fittings. Each length of conduit shall be furnished with one standard coupling. Joints shall be made with solvent cement. All additional conduit couplings, factory bends, plastic-to- steel conduit adapters, solvent cement, and special fittings for the complete conduit system shall be included. Couplings shall have a center stop to ensure proper seating.
All 6 inch and larger PVC elbows shall have a radius of 36" (thirty-six inches); with 5 inch and smaller PVC elbows adhering to recognized standards and procedures. All PVC conduit joints shall be solvent welded in accordance with the recommendation of the cement manufacturer.

All 6” PVC elbows into switchgear shall be backfilled with slurry backfill to prevent conduit from coming loose when power cables are pulled in.

2.4 **Couplings and Thread Protectors**. Each length of threaded conduit shall be complete with a coupling on one end and a thread protector on the other. The thread protector shall have sufficient mechanical strength to protect the threads during normal handling and storage.

2.5 **Flexible Conduit**. All flexible conduit shall be plastic jacketed, liquidtight, galvanized steel, Sealtite Type EF for general service areas or Type HC for high temperature locations. Owner approval is required prior to the installation of each flexible conduit.

2.6 **Metal Conduit Fittings**. All metal conduit fittings shall conform to the requirements of ANSI/NEMA FB1 and UL 5l4 where these standards apply. Galvanized iron or galvanized steel fittings shall be used with steel conduit. All fittings for aluminum conduit shall be copper free aluminum or aluminum alloy.

2.7 **Flexible Conduit Fittings**. All flexible conduit fittings shall be liquidtight, galvanized steel, Appleton Type STN, STB, or acceptable equal, and shall bear the UL label.

2.8 **Special Fittings**. Conduit sealing, explosion proof, dustproof, and other types of special fittings shall be provided as required by the drawings and these specifications, and shall be consistent with the area and equipment with which they are associated. Fittings installed outdoors or in damp locations shall be sealed and gasketed. Outdoor fittings shall be of heavy cast construction.

2.9 **Bushings**. Insulated bushings with insulating inserts in metal housings shall be provided for the termination of all conduit not terminated in hubs and couplings. Grounding type insulated bushings shall be provided for all conduit containing power circuits. Standard bushings shall be galvanized.

2.10 **Locknuts**. One interior and one exterior locknut shall be provided for all conduit terminations not provided with threaded hubs and couplings. Locknuts shall be designed to securely bond the conduit to the box when tightened. Locknuts shall be so constructed that they will not be loosened by vibration.

2.11 **Unions**. Conduit unions shall be acceptable to the Project Field Manager. Watertight conduit unions shall be Crouse-Hinds Type UNF or acceptable equal.

2.12 **Raintight Conduit Hubs**. Raintight conduit terminating hubs, where indicated on the drawings or required by these specifications, shall be Efcor "Water-Tite" rigid conduit hubs or acceptable equal. Malleable iron hubs shall be used for steel conduit.

6.1.46 EXECUTION

Conduit installation shall be as indicated on the drawings and as described in these specifications.

3.1 **Routing**. Except as otherwise specified or indicated on the drawings, all conduit shall be installed in exposed runs parallel or perpendicular to dominant surfaces with right angle turns made of symmetrical bends or fittings. Conduit shall not be installed on the outside face of exposed columns, but shall be routed on the web or on the inside of a flange of the column. Except where prevented by the location of other work, a single conduit or a conduit group shall be centered on structural members. To the extent that it is possible, conduit shall not be unnecessarily routed under equipment foundations.
All conduit field routing shall be acceptable to the Project Field Manager. Routing not acceptable shall be rerouted and replaced without expense to the Owner.

3.2 **Moisture Pockets**. Moisture pockets shall be eliminated from conduits. If water cannot drain to the natural opening in the conduit system, a hole shall be drilled in the bottom of a pull box or a "C-type" conduit fitting provided in the low point of the conduit run.

3.3 **Couplings and Unions**. Metal conduit shall be joined by threaded conduit couplings with the conduit ends butted. The use of running threads will not be permitted.
Where metal conduit cannot be joined by standard threaded couplings, conduit unions or split couplings may be used if their location is acceptable to the Project Field Manager. Only ground seat type watertight unions shall be used outdoors or where the union may be submerged.

Where couplings or unions which do not have ground seats are used in vertical or inclined conduit runs, the coupling nut shall be installed uppermost to prevent the entrance of water into the union.

3.4 **Bends and Offsets**. A run of conduit shall not contain more than the equivalent of four quarter bends, including those immediately at outlets or fittings. Bends in conduit shall be made without reducing the internal diameter of the conduit. The use of a pipe tee or vise for bending conduit will not be permitted. The inside radius of conduit bends shall be not less than six times the inside diameter of the conduit. Conduits deformed or crushed in any way shall be removed from the jobsite.

3.5 **Cutting and Threading**. The plane of all conduit ends shall be square with the center line. Where threads are required, they shall be cut and cleaned prior to conduit reaming. The ends of all conduit shall be reamed to remove all rough edges and burrs.

A cutting oil shall be used in threading operations. The dies shall be kept sharp and provisions shall be made for chip clearance.

All steel conduit, after threading, shall be regalvanized with "Galvanizing Powder M-32l" as manufactured by the American Solder and Flux Company of Philadelphia, Pennsylvania; with "Zincilate 8l0" as manufactured by Industrial Metal Protectives, Inc., of Dayton, Ohio; with "Zinc Rich" coating as manufactured by ZRC Chemical Products Company, Quincy, Massachusetts; or acceptable equal. The Contractor shall supply this protective material and shall apply it in the field.

3.6 **Connections to Boxes and Cabinets**. Conduit shall be securely fastened to all boxes and cabinets. Threads on metallic conduit shall project through the wall of the box to allow the bushing to butt against the end of the conduit. The locknuts both inside and outside shall then be tightened sufficiently to bond the conduit securely to the box.
All conduit entering enclosures outdoors or in wet areas shall enter through watertight hubs or threaded openings.

3.7 **Cleaning**. Precautions shall be taken to prevent the accumulation of water, dirt, or concrete in the conduit. Conduit in which water or other foreign materials have been permitted to accumulate shall be thoroughly cleaned or, where such accumulation cannot be removed by methods acceptable to the Project Field Manager, the conduit shall be replaced.

3.8 **Flexible Conduit**. Flexible conduit inserts not greater than 30 inches in length shall be installed at the locations specified in this article. To the extent that it is possible, conduit shall not be unnecessarily routed under equipment foundations.

Flexible conduit inserts shall be installed in all conduit runs which are supported by both building steel and by structures subject to vibration or thermal expansion.

Flexible conduit shall be installed in conduit runs which cross expansion joints or which connect to building supported independent structures.

Flexible conduit inserts should be considered in all long conduit runs where differential expansion problems may be expected.

3.9 **Plastic Conduit**. Except as specified in the following paragraphs, polyvinyl chloride conduit shall be installed in accordance with the installation requirements previously specified for metallic conduit. Expansion joints for exposed conduit or buried conduit which will be exposed to temperature variations shall be provided as recommended by the manufacturer.
Joints shall be unthreaded solvent cement type as recommended by the conduit manufacturer. The contact surfaces of the conduit and fitting socket shall be cleaned with Stoddard solvent, methyl ethyl ketone, or acetone, liberally coated with solvent cement, promptly and fully engaged, and either conduit or fitting rotated approximately l/4 turn to dispel air and evenly distribute solvent cement over contact surfaces. For proper connection, total elapsed time between the start of the cement application to the surfaces being joined and final assembly of the joint should not exceed 60 seconds. The initial strength of the joint will permit

continuous conduit installation; however, additional stress at the joint shall be avoided for at least 24 hours after joining.

Bends shall be made from straight conduit lengths or shall be factory fabricated. Bend radii shall be in accordance with NEC.

The conduit length for field bending shall be heated to approximately 275 F by radiant heat, hot air, or hot liquid immersion. Open flame heating will not be permitted. Special mandrels or forms shall be used to provide a smooth bend without reduction of the conduit diameter. Conduit discolored by prolonged heating will not be acceptable.

Where plastic conduit is required to be buried directly in the earth as indicated on the drawings, the conduit shall be bedded in a graded 3 inch deep soft bedding of sand or finely divided job excavated material free from debris, organic material, and stones. Backfill, to approximately 6 inches above the conduit, shall be the same as bedding material.

All polyvinyl chloride conduit, including factory bends and sweeps, shall be schedule 40 in accordance with NEMA TC-2.

3.10 **Below Grade Steel Conduit**. Steel conduit shall not be direct buried in the earth. Below grade steel conduit shall be encased with not less than 3 inches of concrete. Concrete used for conduit encasement shall contain not less than 500 pounds of cement per cubic yard. It shall contain clean and well graded aggregates and low water content. The slump shall be such that the mixture is stiff and will stand erect when placed. The concrete shall be vibrated to consolidate it around the steel and shall be slow cured for several days to provide strength and prevent shrinkage. Conduit shall be supported for encasement by steel wire hangers attached to temporary supports laid across the conduit trench. After the concrete encasement has hardened, the supports and those parts of the wire hangers not encased in concrete shall be removed.
A minimum separation of 3 inches shall be maintained between multiple conduits enclosed in the same concrete encasement but not assembled as a duct bank.

Concrete used for encasing steel conduit shall contain no additives which contain chlorides. The concrete shall be mixed with pure, clean potable water.

The Contractor shall field route conduit according to the general routing indicated on the drawings and shall coordinate conduit locations with other work. Conduit shall be accurately positioned and securely anchored before the concrete is poured to encase it.

Conduit which will be visible above the finished floor shall be straight and plumb.

Conduit which is stubbed up shall be plugged prior to pouring of concrete and shall remain plugged until the conduit is extended later.

3.11 **Spacing and Attachment of Supports.** Except where buried in concrete, all conduit runs shall be rigidly supported. Each conduit shall be supported within one foot of junction boxes and fittings. Support spacing along conduit runs shall be as follows:

Conduit Size	Maximum Distance Between Supports
1/2 inch through 1-1/4 inch	5 feet
1-1/2 inch and larger	10 feet

Conduit clamps shall be bolted to building steel using drilled and tapped screw holes. Support channels for three or more conduits shall be welded to building steel or bolted using drilled and tapped screw holes.

3.12 Conduit Fill
Conduit fill shall not exceed guidelines as provided in the National Electric Code. Conduit fill calculations shall consider all cables and conductors in a given conduit.

3.13 **Inspection:** All conduit work, including all associated trenching and backfill, shall be subject to inspection. This inspection or the waiver of inspection by Company shall not relieve the Contractor from his responsibility for use, supply, and installation of materials, workmanship, and all other liabilities specified under the contract.

6.1.47 UNDERGROUND DUCT BANK CONSTRUCTION

Duct banks consisting of individually assembled plastic duct, arranged as indicated on the drawings, shall be furnished and installed in accordance with the following specification. The duct banks shall be concrete encased, direct buried with a protective concrete cap, or direct buried as indicated on the drawings.

6.1.48 MATERIAL

Underground duct system materials furnished under these specifications shall be new and undamaged and shall conform to the following requirements:

Duct	Polyvinyl chloride, Type DB in accordance with NEMA TC-6 for concrete encased duct, Schedule 40 Type TC-2 for direct buried duct.
Couplings	Plastic, for use with duct previously specified and "Duct-to-steel" adapters as required, including joint cement.
Spacers	Plastic high impact, interlocking, base and intermediate type.

Factory bends	PVC, for long radius sweeps. Rigid and sweep galvanized steel (concrete encased) 90 degree bends with 36-inch minimum radius.
End bells	Plastic.
Plugs	Plastic, high impact, tapered to fit end bell provided.
Duct binder	Hemp or sisal twine.
Riser termination	Rigid hot-dip galvanized mild couplings steel.
Riser bends	Rigid steel conduit elbows, factory or field made, 36-inch minimum radius, 90 degree, entirely concrete encased below grade; hot-dip galvanized rigid mild steel in accordance with ANSI C80.1 and UL 6; the conduit interior and exterior surfaces having a continuous zinc coating with an overcoat of transparent enamel or transparent lacquer.
Duct terminators	Formax type with 3-inch separation as indicated on the drawings.
Manhole materials	Shall be as specified and indicated on the drawings.

6.1.49 DUCT BANK INSTALLATION

Each duct bank shall be laid to exact grade in the trench and the ends shall enter manholes, switchgear, or buildings as indicated on the drawings. No dips or low points which retain water in any duct will be permitted in ducts between manholes or between buildings or switchgear and manholes. End bells shall be used on individual ducts at the end of duct banks entering manholes or buildings except where another type of termination is specified or detailed on the drawings. All field bends and sweeps shall be fabricated with straight sections of duct, bent to provide the radius indicated on the drawings.

The ends of the individual ducts shall be cleaned and swabbed with joint sealing compound, and the duct shall then be forced tightly into the coupling to make a watertight connection. The individual ducts shall be laid in place, held by standard spacers placed at 5 foot intervals, and bound with hemp or sisal twine. The ends of the ducts in each of the upper layers shall be stepped back approximately 2 feet from the end of the layer immediately below it. The concrete envelope (when indicated on the drawings) shall be poured after the individual ducts are securely tied in place and adequately anchored and/or weighted to completely counteract the buoyancy of the ducts in the fluid concrete. Care shall be taken in pouring the concrete to prevent the empty ducts from being damaged or displaced, either in grade or alignment.

Defective ducts shall not be installed and shall be removed immediately from the site of the work. Particular care shall be taken to keep concrete or other substances from the inside of the individual ducts during construction. All reinforcing materials and other magnetic materials installed in a duct bank shall be parallel to the lengths of the individual ducts, except for ties enclosing all ducts of the duct bank.

In cases where the conduit passes above or below an underground obstruction such as a utility line, a minimum clearance of 12 inches shall be maintained from the conduit to the utility. A minimum of 12 inches of clearance shall be maintained between the concrete encasement and a paralleling utility.

Two cable marking ribbons shall be installed by the Contractor. The cable marking ribbons shall be installed above the concrete encased conduit, the concrete protective cap, or the direct buried ducts. The ribbons shall be placed side-by-side at a depth of 1 foot 6 inches below grade and directly above the conduit.

6.1.50 Testing and Cleaning

After completion of the duct bank or before cable is pulled into existing duct banks, each duct shall be tested and cleaned, and ducts which will not be used immediately shall be plugged at each end. As a clearance test, each duct shall pass a mandrel with a diameter l/4 inch less than the inside diameter of the duct. All foreign material, earth, sand, and gravel shall be removed from the ducts with circular stiff bristled brushes. A 1/4 inch nylon rope shall be installed in all unused ducts.

45. SECTION 6070 GROUNDING SYSTEM

6.1.51 General

6.1.52 Scope

This section covers the furnishing and field installation of a grounding system and all components. The grounding system and installation shall be in accordance with the drawings and these specifications.

6.1.53 Codes and Standards

Work performed under these specifications shall be done in accordance with the following codes and standards and the applicable codes, standards, and regulations set forth in the BESS Spec. Unless otherwise specified, the applicable governing edition and addenda to be used for all references to codes or standards specified herein shall be interpreted to be the jurisdictionally approved edition and addenda. If a code or standard is not jurisdictionally mandated, then the current edition and addenda in effect at the date of this document shall apply.

Grounding systems and components furnished with these specifications shall be manufactured in accordance with applicable standards of the Institute of Electrical and Electronics Engineers, Inc. (IEEE), the National Electrical Manufacturers Association (NEMA), the American Society for Testing and Materials (ASTM), and Underwriters' Laboratories, Inc. (UL). Grounding systems and components shall be installed in accordance with the applicable requirements of the National Electrical Code (NEC) and the Occupational Safety and Health Administration (OSHA) standards.

6.1.54 SUBMITTALS

Contractor, under the supervision of the Owner, shall submit to the Owner test results of the completed ground grid area. The results include grid resistance and a current injection continuity check of the ground mat. If these results do not comply with the finalized ground grid calculations as defined in M1-04-01-General_Electrical_Study_Requirements, then Contractor will, at their expense and at Owner's approval, make adjustments to the ground grid construction to meet applicable ground grid requirements.

All ground resistance measurements shall be made with the Fall of Potential or slope methods as defined in IEEE 81. Some of the acceptable instruments are as follows: Advanced Geosciences, Inc., Sting R1, Mini Sting, Super Sting R1, or Super Sting R8, Iris Instruments, SYSCAL R1 Plus, SYSCAL R2, or SYSCAL Pro AEMC 6472 & 6474 combination After connection of ground rods to the ground system, the Contractor shall obtain a grid resistance measurement using PGE test procedures with recommended distances. This data shall be obtained, identified, and recorded.

6.1.55 MATERIALS

An electrical grounding system shall be furnished and installed in accordance with the drawings and the following specifications. Grounding components shall include ground rods, ground conductor, ground bus, above and below grade grounding connections, grounding lugs, and hardware required for a complete system.

2.1 Grounding Materials: Grounding component materials shall be furnished new and undamaged, and shall conform to the requirements of the articles that follow.

2.2 **Ground rods:** Unless otherwise stated, ground rods shall be 5/8 inch diameter, 8 foot long, copper clad, cold drawn carbon steel manufactured in accordance with UL 467. The copper cladding shall be electrically bonded to the steel rod or bonded by a molten welding process. Cold rolled copper cladding will not be acceptable. Ground rods shall have a conical taper on one end to facilitate soil penetration.

2.3 **Below Grade Conductors:** Below grade ground conductors shall be soft drawn, 250 kcmil, 19 or 37 stranded, copper cable conforming to the requirements of ASTM B-8.

2.4 **Ground Stingers:** Ground stingers shall be soft drawn, 19#9 stranded copperweld cable, with 40 percent conductivity.

2.5 **Exothermal connections:** Exothermal connections shall be a standard duty copper molten weld conforming to the requirements of IEEE 837, IEEE 80 Section 11, and UL 467. Molds and powder cartridges used for making exothermal connections shall be furnished by the same manufacturer. Exothermal connections shall be similar to Type CADWELD as manufactured by Erico, or an Engineer acceptable equal.

2.6 **Above Grade Ground lugs:** Ground lugs to structures or equipment shall PGE two hole ground clamp provided by Portland Foundry.

2.7 **Below Grade Ground lugs:** Below grade ground lugs shall be PGE approved DMC grounding connector specified in the bill of materials. Below grade Burndy connections are not acceptable. DMC P/N: GC721B025-025 shall be used for 250-250 MCM CU grounding connector. DMC P/N: GC732B025-562 shall be used for 250 MCM – 5/8” rod connector

2.8 **Hardware:** Clamps, connectors, bolts, washers, nuts, and other hardware used with the grounding system shall be of copper, copper alloy, or stainless steel.

2.9 **Ground connectors:** Bolted ground connectors and flexible type grounding jumpers shall be provided for operating handles of disconnect switches. All grounding connectors in contact with galvanized structures shall be tinned bronze material.

6.1.56 EXECUTION

3.1 **Routing**. Except as otherwise specified or indicated on the drawings, all ground conductors shall be installed in exposed runs parallel or perpendicular to dominant surfaces with right angle turns.

All ground field routing shall be acceptable to the Project Field Manager. Routing not acceptable shall be rerouted and replaced without expense to the Owner.

Any ground wire that runs over concrete more than 12” will require an anchor every 12” to the concrete.

The grounding system/grid shall be installed throughout the Project Substation, including at least three (3) feet outside the perimeter fence of the Project Substation and shall be bonded to the fence as required to meet acceptable levels of both touch and step potential and ground potential rise.

3.2 **Trenching and Backfill.** Except as otherwise specified or indicated on the drawings, refer to trenching and backfill section for fill requirements.

Grounding backfill material shall be either job excavated material or material furnished by the Contractor from offsite sources that is similar to job excavated material. The method of compaction and the equipment used shall be appropriate for the material being compacted and not damage the ground grid. Backfill material obtained from off-site sources shall be free of contamination.

3.3 **Conductors**. Unless noted otherwise, all below grade ground conductors shall be buried 18 inches below finish grade. Ground grid conductors under foundations shall have 6 inches of earth cover between conductor and bottom of foundation.

Conductors routed around 90 degree corners shall be kept in close contact with the perpendicular surfaces and shall not be physically damaged due to an insufficient bending radius.

Below grade ground conductors shall be placed as indicated on the drawings.

Damaged ground system conductors shall be repaired or replaced by the Contractor.

3.4 Stingers. All Copperweld ground stingers shall be brought above grade as noted on the design drawings. A 10-foot pigtail shall be coiled and left above grade for future connections to equipment.

Stingers shall not be physically damaged. Any damaged stingers shall be repaired or replaced.

3.5 Ground Rods. All ground rods shall be located as indicated on the drawings and installed to the depth indicated. Where the required ground rod length exceeds 10 feet (3 m), ground rod standard sections shall be welded together to provide an extended rod with one true centerline. During welding, the ground rod sections being welded shall be supported by a guide to ensure proper alignment.

3.6 Connections. The manufacturer's instructions on the use of exothermal welding materials shall be followed in all details.

All surfaces to be joined by the welds shall be thoroughly cleaned. Powder cartridges and molds shall be kept dry and warm. Worn or damaged molds shall not be used.

All exothermally welded connections shall successfully resist moderate hammer blows. Any connection which fails such test, or which upon inspection indicates a porous or deformed weld, shall be remade.

All exothermal welds shall encompass 100 percent of the ends of the materials being welded. Welds that do not meet this requirement shall be remade.

All bolted and screwed connections shall be securely tightened.

3.7 Column Grounding. Structural steel columns shall be grounded as indicated on the drawings. Prior to the installation of the servit post, paint, scale, and other non-conductive substances shall be removed from surfaces of un- galvanized structural steel members by grinding. Galvanized steel surfaces shall be cleaned with emery paper.

3.8 Conduit Grounding. All conduit grounding bushings within all enclosures, including equipment enclosures, shall be wired together and connected internally to the enclosure grounding lug grounding bus with a bare copper conductor. Grounding bushings shall be grounded with conductor sized in accordance with the NEC, but not smaller than 8 AWG.

All grounding bushings on conduit runs which are terminated at tray shall be connected to the tray grounding cable or tray side rail with bare copper conductor as indicated on the drawings.

Where a conduit run is terminated at tray and the conduit carries a separate insulated grounding conductor, this grounding conductor shall be terminated on the tray grounding cable. If the conduit run is terminated with a grounding bushing and the separate ground conductor it carries is sized in accordance with the requirements of the preceding paragraphs for conduit bushing grounding, the ground conductor in the conduit run may be continued through the conduit bushing ground connection and terminated on the tray grounding cable making unnecessary the installation of a separate conduit bushing grounding cable.

Conduit bushing ground conductors shall be connected to the tray ground cable using split bolt connectors or an Engineer acceptable equal mechanical connector.

Conduit terminated at equipment and device in threaded hubs shall not require additional grounding provisions.

3.9 Tray Grounding. A bare copper grounding conductor shall be installed on all power level cable trays containing single conductor power cables. The tray grounding conductor shall be installed on the outside of the tray side rails, along the entire length of the trays, attaching to each tray fitting and to each straight section of tray at 6 foot (1.8 m) maximum intervals. The tray grounding conductor shall be attached to the trays using bolted ground clamps, and shall be connected to the ground grid at locations indicated on the drawings. Splices for the tray grounding conductor shall be made using compression connectors.

Cable trays containing multi-conductor power cables, control, or instrument circuits shall not require a continuous ground conductor installed along the tray. Instead, these tray levels shall be grounded by means of a ground jumper extended from the tray side rail to the continuous ground conductor installed along a power level cable tray, to building steel, or to the ground grid. Grounding intervals shall not exceed 100 feet (30 m).

Grounding jumpers shall be required across all expansion splice plates, dropouts and adjustable splice plates where a continuous ground conductor is not installed along the tray level.

3.10 Equipment Grounding. Electrical equipment that requires a ground grid extension stinger shall be connected to the ground grid with copper grounding conductor as indicated on the drawings. The term "electrical equipment," as used in this article, shall include all enclosures containing electrical connections or bare conductors except that individual devices such as solenoids, pressure switches, and limit switches shall be exempt from this requirement unless the device requires grounding for proper operation. Large electrical power distribution equipment such as medium or low voltage switchgear or motor control centers will be furnished with a ground bus which the Contractor shall connect to the ground grid at each end of the ground bus. Other equipment will be furnished with grounding pads and/or ground lugs which the Contractor shall connect to the ground grid. All ground connection surfaces shall be cleaned immediately prior to connection.

Where ground grid extension stingers are indicated on the drawings to be provided for connection to electrical equipment, the Contractor shall connect the grounding conductor to the equipment ground bus, pad, or lug. In addition to the ground grid extension stingers, a ground conductor shall be provided from the tray ground cable to the incoming line end of the ground bus in each assembly of medium or low voltage switchgear and motor control centers indicated on the drawings.

Where a ground conductor is included with the phase conductors of power circuits, the ground conductor shall be connected to the equipment grounding facilities and to the source ground bus. Where a ground conductor is not included with the phase conductors, the equipment shall be grounded by connecting a separate ground cable to the equipment grounding facilities and to the tray ground cable or source ground bus.

Except where otherwise indicated on the drawings, all equipment ground conductors which are not an integral part of a cable assembly shall be sized in accordance with the requirements of NEC. All ground conductors installed in conduit shall be insulated.

Circuits in the circuit List include an insulated ground conductor to all 6,900 volt, 4,160 volt, 480 volt, and 208 volt loads to satisfy the requirements of the preceding paragraph. This ground conductor is either a separate cable, Type GI, or is contained within the multi-conductor power cable. Power circuits from 120/208 volt power panels contain one additional conductor which is used for grounding smaller devices which require 120-volt power. Additional grounding cables which would duplicate the ground conductors already in the Circuit List are not required.

The Contractor shall design, furnish, and install all equipment grounding cables required in addition to the ground cables contained in the Circuit List. This shall include, but not be limited to, devices which have electrical connections but do not require a power circuit such as junction boxes and control equipment enclosures, any equipment to which the routed ground conductor is not of sufficient size to properly ground the equipment, and any other electrical equipment which is not grounded by means of a conductor in the Circuit List.

Suitable grounding facilities shall be furnished on electrical equipment not so equipped. The grounding facilities shall consist of compression type terminal connectors bolted to the equipment frame or enclosure and providing a minimum of joint resistance.

Suitable grounding facilities for electrical equipment not so equipped, but requiring multiple grounding connections, shall include the installation of a bare copper ground bus for the connection of several grounding conductors. This ground bus shall be connected to the equipment frame or enclosure, providing a minimum of joint resistance.

The conduit system is not considered to be a grounding conductor except for itself and for lighting fixtures. No equipment grounding conductor shall be smaller in size than 12 AWG unless it is a part of an acceptable cable assembly.

3.11 **Duct Bank** One bare copper ground conductor, equal in size to the ground grid conductors, shall be routed with each duct bank as indicated on the drawings. The duct bank ground conductors shall be located at the top of the duct bank and physically separated on each side if two are required. The duct bank ground conductors shall be connected to the ground grid and grids at locations where the duct bank crosses the grids as indicated on the drawings.

3.12 **Vault Grounding**. A ground conductor, equal in size to the ground grid conductors, shall be grounded at the vault at one end only as indicated on the drawings.

3.13 **Fence and Gate Grounding**. Use PGE Standard S-140-15 for fence and gate grounding requirements.

3.14 **Barb Wire Grounding.** Use PGE Standard S-140-16 for barb wire grounding requirements.

3.15 **Instrument Transformer Grounding.** Use PGE Standard S-140-24 for instrument transformer grounding requirements

3.16 **Switch Handle and Operator Grounding.** Use PGE Standard S-140-27 for switch handle and operator grounding requirements.

3.17 **Power Transformer Grounding.** Use PGE Standard S-140-31 for power transformer grounding requirements. The neutral connection to the transformer shall be one continuous connection from the X0 bushing to ground. Power transformer grounding materials and terminations shall comply with requirements as set forth in M1-04-02 (General Transformer Specification), equipment manufacturer specifications, and equipment manufacturer drawings. Contractor shall seek Owner approval of power transformer grounding installation in the event that power transformer equipment grounding requirements are not consistent between equipment manufacturer documents and Owner specifications.

3.18 Capacitor Bank Grounding. Use PGE Standard S-140-09 for capacitor bank grounding requirements.

3.19 Gas Insulated Switchgear (GIS) Grounding. GIS grounding shall be accordance with drawings and manufacturer’s recommendation. Refer to manufacturer GIS grounding information document in the attachment.

46. SECTION 6080 YARD LIGHTING

6.1.57 GENERAL

6.1.58 SCOPE

The work covered by this specification includes furnishing of all labor, tools, and equipment necessary to install the yard lighting and convenience receptacles in the substation / switchyard as shown on the drawings and as specified herein.

6.1.59 CODES AND STANDARDS

Comply with the provisions of the following codes, specifications and standards, except as otherwise shown or specified, as well as the applicable codes, standards, and regulations set forth in the BESS Spec. The latest edition of the code or standard shall govern:

NFPA 70 – National Electrical Code

National Electrical Safety Code Section 111

6.1.60 MATERIALS

All materials furnished by the Contractor shall comply with the specifications, the results of the substation lighting study as defined in M1-04-01-General_Electrical_Study_Requirements, and drawings and be approved by the Owner.

Miscellaneous materials provided by the Contractor shall meet the following criteria:

Component	Material
Switches	
Housing and operating levers	Phenolic compound
Device plates	
Finished areas (metal)	Type 430 satin stainless steel
Unfinished areas	Formed sheet steel coated with zinc of cadmium

Weatherproof receptacle and switches	
Plates and lift cover	Cast aluminum
All other metal parts	Stainless steel or Monel metal

The following conductor types for use in the lighting and convenience receptacle circuits shall be provided.

Cable Type	Circuit Use
THHN (Type L2)	For 120 volt circuits in heated areas
XHHW-2 (Type L1)	All 277 volt circuits and all 120 volt circuits in unheated areas
SF-2 (Type SF-2)	For incandescent luminaire connections

The following raceway and raceway fittings for use in lighting and convenience receptacle circuits shall be provided:

Raceway Type	Use
Electrical metallic tubing (EMT)	Installed in indoor non-hazardous areas
Rigid galvanized steel or Rigid aluminum	Outdoors above grade and indoor hazardous areas
Flexible metallic tubing	Luminaire taps in finished areas
Schedule 40 PVC	Area lighting routed underground

6.1.61 EXECUTION

3.1 Lighting units, receptacles and boxes shall be installed on structures and in the control house as shown on the drawings. Installation of conduit, conduit fittings and boxes for yard power system is covered in the "Conduits" section (6060). Contractor shall install all lamps and poles as indicated in the drawings.

3.2 **Wiring:** Contractor shall install insulated wire, of type and sizes shown on the drawings, to connect control house, yard lighting, and convenience receptacles.

All joints in wiring shall be carefully and thoroughly soldered, or pressure type solderless connectors may be used. If connections are soldered, they shall be insulated with electrical plastic tape or rubber tape covered with black friction tape. If connectors are used, they shall be properly capped or taped.

Immediately before energizing a lighting or convenience receptacle circuit, the Contractor shall make the following checks:

- The transformer neutral supplying the source panelboard is solidly connected to ground.
- The phase and neutral conductors to be energized are free from grounds.
- Convenience receptacle polarity is verified and tested.
- Ground fault circuit interrupting (GFCI) devices are tested for proper operation.
- All covers are installed on luminaires, wiring devices, pull boxes, junction boxes, and conduit fittings so exposed conductors will not be energized.
- The ground conductor is solidly grounded.

The Contractor under the supervision of the Owner representative shall test all circuits for continuity, grounds and shorts, and shall correct all faulty or improperly connected circuits to the satisfaction of Owner.

3.3 **Inspection**: All electrical wiring work shall be subject to inspection. This inspection or waiver of inspection by Owner shall not relieve the Contractor from entire responsibility for use, supply, and installation of materials, workmanship, and all other liabilities under the contract.

47. SECTION 6090 EQUIPMENT TESTING AND ENERGIZATION

6.1.62 GENERAL

6.1.63 SCOPE

This section describes and defines general criteria which pertain to the testing and checkout work covered by these specifications. The scope of work extends to all equipment connected and/or installed under these specifications. This work is in addition to testing activities required in other sections of this specification. The Contractor shall be responsible, as part of the base scope, for all labor and materials required to demonstrate that all equipment has been installed correctly and functions properly.

The Contractor test procedures and plans must meet NETA and IEEE standards for testing. The Contractor shall document all testing and inspections

The Contractor shall supply to the Owner their proposed Electrical and Instrumentation Testing procedures for review.

All checkout and testing shall be performed and approved by a Contractor specializing in this type of work. All pre-energization testing shall be completed by Contractor and approved by Owner prior to substation energization.

The cost of all labor, supervision, materials, equipment, vehicles, supplies, and services necessary to provide field tests and adjustments required to demonstrate that electrical systems are correctly installed, tested, and calibrated shall be included in the Contractor’s base lump sum price.

The Contractor is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

The Contractor shall notify Owner of all Subcontractors that will be used for testing during the bid process.

Prior to commencement of substation energization procedures, Contractor shall submit, and Owner shall approve, a substation energization plan that includes, but is not limited to, a step-by-step checklist that verifies changes in equipment status (i.e. circuit breaker open, disconnect switch closed) including lock-out tag-out procedures, safety precautions including a “STOP WORK” authority and an “ALL CLEAR” signal, coordination with the interconnecting switchyard/substation owners to energize the interconnecting switchyard/substation circuit breakers and interconnecting transmission line, and listing of key authorized personnel. This energization plan shall appropriately coordinate with any collection energization plans and procedures.

6.1.64 WORK PERFORMED BY CONTRACTOR

The following activities shall be performed as part of the equipment installation. The Contractor shall perform all mechanical and electrical work required to calibrate, checkout, and make the equipment ready for service as required by these specifications.

- Visual and mechanical inspection of equipment.
- Mechanical adjustment and testing of all electrical equipment, as required, assuring proper mechanical functioning and operation.
- All testing and reconnection necessary to obtain correct operation of the electrical equipment.
- Loop verification of all control and instrumentation circuits, in accordance with the Circuit List, to confirm continuity of conductors and those conductors originate and terminate at the locations designated in the circuit list or on the drawings.
- Contractor shall verify expected relay and SCADA inputs (52a, BFI, control switch inputs to relay, etc.) Interrogating the relays and observing expected inputs. Contractor shall verify and exercise relay outputs contacts with relay commands to ensure proper function of the associated circuits (e.g. trip circuits, close circuits, lockouts, etc.)
- Control wiring shall be confirmed as complete and ready for functional testing prior to starting functional testing.
- Functional testing shall include a demonstration that all equipment installed can be operated in accordance with their specification.
- All equipment labeling shall include type and location information and shall be verified as installed and accurate.
- All mechanical adjustment necessary or recommended by the manufacturer of all Contractor-supplied or Owner-supplied electrical equipment being connected or installed.
- Complete testing of the lighting and receptacle system as applicable.

- All instruments wired and calibrated, even if installed by others.
- The Contractor shall perform all tests described in the Testing Checklist for Contractor (TCC)
- Upon acceptance of completion, the Contractor shall provide standby craft labor to correct discrepancies found during initial operation on a time and material basis when requested by the Owner. Such standby craft labor shall not be utilized for completion of Contractor punch list items for work later identified as resulting from Contractor's lack of construction completion or Contractor's warranty work.

6.1.65 Work Performed by PGE

- Protective relaying testing will be performed by Owner.
- Electrical Testing of the transformer will be performed by Owner with assistance provided by the Contractor
  - Testing of the transformer will be performed as soon as possible after the transformer is fully assembled
  - Contractor will provide owner notification 2 weeks in advance of a 3 day window when the Owner may test the transformer.
  - Owner will provide technicians and the required equipment to complete the electrical testing.
  - The Contractor shall provide all other workers required to make adjustments, connect equipment, and correct deficiencies during the testing

6.1.66 Codes and Standards

Testing shall be conducted in accordance with the specified source.

Tests	In Accordance With	Conducted By
Acceptance Testing	IEEE, NETA	Contractor

6.1.67 Materials

The Contractor shall provide all necessary material and equipment required for the functionality testing of all major equipment indicated.

6.1.68 Execution

The Contractor shall inform Owner that specific items, devices, or systems are installed and available for checkout. Documentation of the Inspections and Testing will be done on Testing Checklist for Contractor (TCC). This form will be supplied by Owner.

Inspection. The Contractor shall inspect the installed instrument systems and the installed equipment specified herein prior to starting calibration and checkout and shall report in writing to Owner all deficiencies that could prevent proper checkout of such equipment and systems. Such deficiencies, if caused by or during installation by the Contractor, shall immediately be corrected.

Discrepancy Procedure. The Contractor shall endeavor to promptly discover major discrepancies in equipment, materials, and installation so that corrective procedures can be initiated without delay. When the Contractor discovers equipment with an incorrect rating, damage, not being as specified, or is otherwise unsatisfactory, arrangements will be made for replacement of the equipment. The Contractor shall promptly report to Owner any improper field installations or material usage which the Contractor believes should be corrected. Owner will arrange for corrective action.

Calibration in-Place. All equipment furnished and installed by the Contractor shall be calibrated at the site after installation. The Contractor's technicians performing the calibration shall be experienced in the calibration and adjustment of mechanical equipment. Technicians shall be experienced in working with the necessary diagrams and documents in accordance with the calibration and checkout work assigned to each technician.

Devices and equipment shall be adjusted and calibrated with the equipment normally installed in place. Exceptions to this procedure will be permitted with the concurrence of the Owner for the specific device categories for which in- place calibration is not practical.

3.1 Minor Corrections. Equipment and devices furnished by others may require minor correction to ensure correct operation following calibration and checkout. These minor corrections may include the following:

- Minor assembly operations within instruments.
- Removal of factory shunts or jumpers.
- Minor wiring corrections.

The Contractor shall perform minor corrections as part of the work defined by these specifications. In such cases, the Contractor shall include repair of these discrepancies as part of this work.

3.2 Contractor-Caused Defects. The Contractor shall promptly repair at no additional cost to Owner any equipment or devices which are damaged by the Contractor's personnel in the course of performing the work. Such defects shall be promptly reported Owner.

3.3 Manufacturers' Procedures. Drawings and installation and operating instructions from manufacturers of the equipment appropriate to the work described in these specifications will be made available to the Contractor as required. The Contractor shall follow the manufacturers' instructions in the performance of this work and perform all required and recommended tests, calibrations, and settings identified in these instructions.

3.4 Personnel. The Contractor shall provide all personnel required to complete the work in accordance with the project schedule. The Contractor shall provide sufficient staff so that the project schedule is met.

Owner will have the authority to approve and require changes in the Contractor's actual manpower level, including the number of technicians and craft personnel.

The number authorized and required may be above or below the Contractor's planned number.

Personnel not performing efficiently, in the opinion of Owner, shall, upon notification to the Contractor, be immediately removed from the project.

Personnel provided by the Contractor shall include the following classifications.

- **Electrical and Instrumentation Technicians.** The Contractor's technicians shall be experienced in the calibration and adjustment of electrical apparatus, instrumentation, control equipment, and final drive devices. Technicians shall be experienced in working with control electrical schematic and wiring diagrams, electrical one-line diagrams, and electrical three-line diagrams in accordance with the calibration and checkout assignment. The total cost of the technicians shall be included in the base Contract Price.
- **Craft.** Sufficient numbers of craft personnel shall be provided by the Contractor to support completion of the work included under these specifications. The total cost of craft for the level of foreman, journeyman, and apprentice for startup and checkout activities is included in the base Contract Price.

3.5 Tools and Test Equipment. The Contractor shall provide all required tools and test equipment to perform the work in accordance with these specifications and the project schedule. The test equipment shall be periodically certified. Any test equipment found out of tolerance during certification shall be replaced or repaired. The Contractor shall include a list of test equipment provided, including manufacturer and model with the proposal. The Contractor shall provide the Owner with a copy of all certifications for test equipment used on the project including any recertification's or replacement certifications.

3.6 Test Instrument Certification. The Contractor shall provide and maintain an onsite facility to perform periodic certification of test instruments and equipment. Test instruments subject to drift or nonobvious miscalibration shall be certified at least weekly. The Contractor's QA program shall be capable of providing verification that the certification is being performed.
Certification methods shall follow recommendations of the test instrument manufacturers.

The Contractor's personnel performing certification shall be specially trained in the methods and procedures for carrying out these calibration certifications.

3.7 Calibration or Testing Certification Sticker. The Contractor shall furnish and affix a self-adhesive label to each device calibrated or adjusted. The label shall indicate the date and the name of the person performing the calibration or adjustment.

3.8 Checkout and Test Report Forms. The Contractor shall complete the Testing Checklist for Contractor (TCC) for all instruments, mechanical devices, and electrical devices that are tested or calibrated. A blank form to be used by the Contractor will be furnished by Owner or alternately, the

Contractor's standard forms may be used if accepted in writing by Owner. No increase in contract price will be allowed for not using the Contractor's standard forms. The completed forms shall be submitted to the Owner as part of the turnover package. The forms submitted shall include but not be limited to the Checkout and Test Report Forms listed at the end of this section.

Forms shall be submitted within 5 calendar days after completion of the activity covered by the Checkout and Test Report Form.

3.9 **Equipment Checks and Calibration**. Preoperational checks and inspections shall be performed on all equipment as specified herein, and in accordance with the equipment manufacturer's recommendations. A representative of the Contractor shall be present during the equipment checks.
The Contractor shall verify in writing that all work and preoperational checkouts have been completed and, when the services of equipment manufacturers' field service representatives are required, the Contractor shall include verification by such representatives that the equipment is ready for operation.

3.10 **Electrical and Instrumentation Checkout.** This article defines the scope of electrical and all instrumentation devices and equipment which shall be calibrated in-place, adjusted, or checked out by the Contractor as part of the work covered by these specifications.
The Contractor shall perform all tests described in the Testing Checklist for Contractor (TCC).

The Contractor shall provide all temporary instrumentation and gauging devices required during testing and checkout of the equipment and systems.

3.11 **Equipment Checks**. Preoperational checks and inspections shall be performed on all equipment as specified herein and in accordance with the equipment manufacturers and Owners recommendations. All field tests shall be witnessed by the Owner at the Owner's discretion. The Contractor shall perform all tests described in the TCC.
Preoperational checks shall include, but not necessarily be limited to, the following:

- <u>Safety Equipment</u>. All personnel safety items shall be installed. All bolting shall be securely tightened to the correct torque as recommended by the equipment manufacturer.
- All temporary shipping braces, blocks, or tie rods shall be removed.
- <u>Lighting and Receptacle Checkout</u>. The Contractor shall test, check out, and energize the lights and receptacles furnished and installed under this Contract. Lights shall be energized as soon as circuits are complete to increase the lighting level for construction and checkout. Immediately before energizing a lighting or receptacle circuit, the Contractor shall make the following checks

- The phase and neutral conductors to be energized are free from grounds.
- All covers are on lighting fixtures, pull boxes, and junction boxes so exposed conductors will not be energized.

- The ground conductor (if required) is solidly grounded.
- All metering, including panel meters and transducers, shall be calibrated to within the manufacturer's accuracy.
- Panel instrumentation indicating lights, switches, and relays shall be adjusted and checked out as part of the checkout of the Contractor- installed electrical equipment. Electric metering for volts, watts, amperes, and other electrical quantity functions shall be checked out as described in this article and the TCC.
- Electrical panel instrumentation shall be calibrated.
- Unless specified otherwise, all meters shall be tested and calibrated with equipment of no more than 50 percent of the manufacturer's stated accuracy instrument being tested.
- All meters shall be visually inspected for damage, and wiring connections shall be verified in accordance with the three-line diagrams.
- Every instrument utilizing a plastic lens or window shall be given a static effect check. The static check shall consist of wiping the lens or window vigorously with a dry cloth of a type recommended by the manufacturer which will not harm the surface. If the needle or pointer holds up-scale or below zero set for more than 15 seconds, the surface of the lens or window shall be treated with a clear antistatic compound recommended by the manufacturer.
- The Contractor shall verify that direct grounds do not exist on any dc or 480 volt powered systems. Should a ground be detected, the Contractor shall locate the ground source and inform the Owner.
- Measurement of resistance to ground shall be made of all switchgear, overhead bus and panelboard bus immediately prior to placing in service. Measurement of resistance will be with a line operated tester. Voltage of testing device shall be in accordance with the following table or the equipment manufacturer's recommendation, as directed by the Owner:

Equipment Voltage	Voltage, dc	Test Current, max, mA
480 volts	1000 volts	3
4.16 kV	2 kV	1
Above 4.16 kV	5 kV	1

- All 5 kV and above power cable shall be tested (hi-pot, VLF, tan=delta, or partial discharge) in accordance with IEEE and ICEA standards, and in accordance with Startup and Testing Specification.
- Complete check of all field wiring shall be made after installation and connection to verify that field wiring is as indicated on the drawings and schematic wiring diagrams. Equipment jumpers as indicated on the

schematics shall be checked.

- Shielded cable ground check should be made after termination is complete using a volt-ohm meter to determine that each is grounded only at the points indicated on the drawings.
- All instrument transformers, including bushing current transformers, shall be tested.
- Ratio and polarity tests shall be performed on all instrument transformers. Current transformer ratio and polarity tests shall be voltage ratio tests using a digital voltmeter or current ratio tests using high current injection test equipment, as directed by the Engineer.
- The external circuit for each current transformer shall be completely tested before the shorting devices are removed from the current transformer secondary terminals. The tests shall include the following:
- Continuity check of the circuit external to the current transformer by application of current.
- Phase check to verify correct phase relationship at each device connected in the current transformer circuit.
- All protective and alarm devices associated with all power transformers with primary voltage of 4160 volts or higher shall be tested for correct operation and adjusted as required according to the manufacturer's recommendations.
- The Contractor shall verify in writing that all work and checkouts have been completed, and when the services of equipment manufacturer's

  field service representatives are specified, the Contractor shall include verification by such representatives that the equipment is ready for trial operation.

3.12 **Corrected Drawings**. Owner will furnish three sets of the substation Issued for construction design drawings to the Contractor for markup purposes:
The Contractor shall neatly and legibly mark each set, in duplicate, including all field corrections performed during calibration and checkout. One copy of each drawing shall be submitted to PGE as a part of the completed forms returned at startup. A second set will be turned over to Owner for use by Startup and Operations during commissioning. Submittal of these two sets to Owner shall be concurrent with completion of the startup. The third copy shall be retained by the Contractor until the conclusion of the project. The Contractor's copies shall be turned over to Owner at the conclusion of the project.

The Contractor shall use the following colors on markups: Red – Additions

Green – Removals Blue – Information

Yellow – Quality Assurance Checks

3.13 **Checkout and Test Form.** The Contractor shall perform all tests described in the Testing Checklist for Contractor (TCC) provided with the drawings and documents. The Contractor shall initial and date all tests on this document and turn it over to Owner at the conclusion on the project. Contractor shall use Owner forms where applicable for testing documentation.

Appendix M1

Attachment 05

Exhibit 04

Communication, SCADA, and Metering Facilities

RENEWABLE ENERGY RESOURCES

PORTLAND GENERAL ELECTRIC

2023

REQUEST FOR PROPOSAL

NO.	DATE	REVISION	BY	CHK'D	APPROVALS	
0	26Oct21	Issued for Implementation	1898 & Co.		JAL	Jared Lathrop
1	14Apr23	Update from 2021 Version	1898 & Co.	PGE	CPA	Craig Armstrong
2	25Aug23	Rev 2, see redline changes throughout	Jeremy Morris	Craig Armstrong	CPA	Craig Armstrong

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1 M1-05-04-Communication, SCADA, and Metering Facilities

1.1 Communication Facilities

1.1.1 GENERAL

1.1.2 SUMMARY

A. This Section summarizes the communications systems the Contractor shall provide as part of their proposal. The following specifications include detailed SCADA specification sections:

1. M2-01-01 (Wind Plant Specifications)
2. M3-01-01 (Solar Photovoltaic Plant Specifications)
3. M4-01-01 (Energy Storage Technical Documents)

B. The SCADA section in those specifications includes the following:

1. General
2. Main SCADA Components
3. SCADA Device Requirements
4. Interfaces
5. Fiber Optic Network Design
6. Fiber Optic Installation
7. Fiber Terminations and Testing
8. Availability and Reliability
9. Cyber Security
10. Viewing and Display
11. Reporting
12. Support for Warranty Calculations
13. Remote Alerts
14. Time Base and Date Formats

C. This Section summarizes the communications systems not covered within those specifications.

D. The proposal shall address four aspects of the telecommunications design.

1. Intra-site Communications - the Network shall primarily be an Ethernet Fiber network to support intra-site data and voice communications needs.
2. Substation Interconnect - Contractor shall incorporate plans for the communications needs required to interconnect the facility to the bulk electric power system. This may include transfer trip and any of special or remedial protection schemes needed for the interconnection of the facility to the bulk electric power system. This design shall meet any requirements from the interconnecting utility, the Public Utility Commission, and/or the Independent System Operator for SCADA or Metering.
3. PGE Connectivity - to support remote monitoring and operation of the facility. This will include one or more data links back to PGE operations center. This shall include connectivity for both the Primary SCADA link as well as the plant operational data link serving plant operations such as sending operational and maintenance data to a historian, allowing remote access and control, and voice communications to the facility.
4. PGE Local Data Collection – a data collection system will be installed to interface directly with the local plant control system (OEM SCADA) for the purposes of data collection, aggregation, and reporting.

1.1.3 TELECOMMUNICATIONS APPROACH

A. The Contractor shall provide a bid that both meets these specifications and allocates a budget for the design, procurement, and construction of these telecommunications facilities. The site network and the interconnection requirements should be known and the design and costs of these facilities should be accounted for and well understood. The communications link to PGE will depend greatly on the location, size, and type of facility proposed, and therefore the Contractor shall propose a solution that meets these functional specifications. Contractor shall coordinate the communications systems for Substation and O&M Building to ensure compatibility and cost effectiveness and obtain owner’s approval. During negotiations, this aspect of the design may be revised based on site specific conditions. An allowance for each of these four sections (Intra-site Communications, Substation Interconnect, PGE Connectivity, and Local Data Collection) shall be provided. The proposal price will not be revised if the ultimate solutions remains within these allowances.

1.1.4 TELECOMUNCATIONS FACILITES

A. The facilities shall consist of the following:

1. Communications during construction: The Contractor shall provide a communications network to be used during construction, and specifically communications services to the on-site trailers used during construction. A minimum of 5 Mbps Ethernet link shall be provided to each PGE trailer, along with (2) phone lines per trailer, which may be either VOIP or POTS. The Ethernet link shall only be dedicated to PGE and no other users.

2. Intra-Site Network: The Contractor shall provide a data network that extends from a central substation or O&M building to all equipment enclosures throughout the facility that house microcontroller equipment.

   a. This network shall be constructed such that it supports the following applications:

      i. Shall support the Real-time control for the operation of the plant.

      ii. Shall support remote monitoring for the Owner to gather operational data from microprocessor-controlled equipment.

      iii. Shall support monitoring of weather information.

      iv. Shall allow the Owner to remotely access remotely configurable equipment to make settings changes and firmware upgrades.

      v. Shall support the use of Voice at each enclosure, desk, conference room, or security control point.

      vi. Shall support the use of Video where required for security and operations of the plant.

      vii. Shall include Wireless Access Points in Office locations.

      viii. Offices and conference room areas will have multiple data/analog wall jack locations. Each location will have two CAT6 station cables home run back to the Communications room where it will terminate in the main distribution field (MDF) enclosure on a specified 110 patch panel.

b. The network shall be capable of meeting the following specifications:

   i. Use IP/Ethernet communications over a fiber and copper network.

   ii. At least 60 Strands of single mode (SM) fiber shall be installed between all buildings as part of the project. Fiber shall be configured in a logical ring and where possible into a diverse optical ring.

   iii. Category 6 copper shall be used for all connections between switches and equipment within a building.

   iv. Use gigabit Ethernet connections

   v. Use VLANS for segmentation of traffic

   vi. Use Quality of Service to Prioritize traffic flows

   vii. Use Rapid Spanning Tree or other advanced ring convergence protocols.

   viii. Support POE where phones or wireless access points are installed.

   ix. Use managed equipment that support the following:

   x. Centralized authentication via RADIUS or TACACS

   xi. Centralized logging via Syslog

   xii. Use hardened network equipment rated for the environment in which it will be installed.

3. Interconnection to Bulk Electric Power System:

   a. Determine specific equipment required by the Utility/Transmission Owner and the System Operator, specifically relating to SCADA, metering, and telemetering due to the interconnection agreement as well as equipment required to complete the indicated control and protection requirements.

   b. Build any fiber, microwave, or leased facilities needed in order to tie facility into bulk electric power system.

c. Follow Western Electricity Coordinating Council (WECC) teleprotection standards.

4. PGE Communications Circuits:

a. Contractor shall provide the following communication circuits, each with the respective parameters given. These communications circuits can be delivered over the one or more aggregate leased circuits if possible. These circuits may make use of a private data network or a leased facility from a common carrier. The Contractor's proposal shall include the capital cost for construction, as well as the estimated monthly recurring cost if applicable. The Contractor shall make use of the PGE equipment listed below where such equipment is required:

Circuit Name	**LOC A**	**LOC Z**	**Type**	**Capacity**	**Latency**	**Avail.**	**Circuit Description**
O&M CORPORATE NETWORK	O&M	PGE WHQ	ETH	25 Mbps	100 msec	99.00%	CORPORATE NETWORK SERVICE
INTRA-SITE NETWORKING	SUBSTATION	O&M	ETH	1 Gbps	0.05 msec	99.00%	CORP NETWORK & SECURITY LAN
SUB REMOTE ACCESS LAN	SUBSTATION	PGE WHQ	ETH	1.5 Mbps	0.5 sec	99.00%	REMOTE ACCESS LAN FOR PROTECTION & AUTOMATION GROUP
SUB COMM TECH LAN	SUBSTATION	PGE WHQ	ETH	1.5 Mbps	0.5 sec	99.00%	REMOTE ACCESS LAN FOR COMM TECHS
PRIMARY AGC+SCADA	SUBSTATION	PGE WHQ	ETH	64 kbps	0.5 sec	99.95%	SERIAL DNP 3.0 AUTOMATIC GENERATION CONTROL AND SCADA
SECONDARY AGC+SCADA	SUBSTATION	PGE WHQ	ETH	64 kbps	0.5 sec	99.95%	SERIAL DNP 3.0 AUTOMATIC GENERATION CONTROL AND SCADA
METERING	SUBSTATION	PGE WHQ	ETH	64 kbps	0.5 sec	99.90%	METERING DATA

1.1.5 OTHER COMMUNICATIONS CIRCUITS/SERVICE

PGE will not be responsible for any Vendor’s long-term ISP or phone system at the site.

1.1.6 TELECOMMUNICATIONS EQUIPMENT

A. In each major facility provide space for (4) adjacent Communications racks. For the Plant and Switchyard/Substation facilities, locate the Communications racks in the same room or adjacent to the relay equipment racks. For the O&M Building or Administration Building, in addition to the Communications racks, provide (4) racks for IT Operations and (2) racks for Corporate Security Operations. Locate the Communications racks in the same room or adjacent to racks dedicated for IT Operations and Corporate Security. Each room to include 4’x8’ fire-rate plywood backboard (white). Cabinets shall be installed with 36” clearance in rear of cabinets and 42” in the front. 36” clearance must also be allocated on the sides of the cabinets unless adjacent to another cabinet or communications rack.

B. Provide a -48VDC power system capable of supplying the load with an 8-hour reserve time at each major facility.

C. Communications equipment shall be grounded per Motorola R56 standards in O&M and Administration Buildings. Grounding in the Switchyard/Substation shall follow IEEE 80 standard industry practices.

D. Provide a SATRAD-G2 satellite phone system with exterior antenna, rack mount equipment, and a dedicated desk phone.

E. Equipment specified for this project shall be of the same manufacturer and model as PGE uses in their existing communications systems:

1. Dual-post Rack – Chatsworth “Clear”, 19” x 84”
2. Ethernet Switch – Cisco
3. VoIP Phone - Cisco
4. Wireless Access Point – Cisco
5. Service Aggregation Node – Nokia 7705-SAR-8 with support cards
6. Fiber Patch Panel – Clearfield FxDS, with SC/UPC Connectors
7. ADSS Fiber Cable – OFS AT-3BE17NT-060-CMEA (60-CNT)
8. OPGW Fiber Cable – AFL DNO-8234 (48-CNT)

9. Splice Cases – Tyco FOSC-450D
10. -48 VDC Fuse Panel – Telect GMT Dual Feed 20/20-position
11. -48 VDC Charger Panel – Valere; CK4D-ANL-VC shelf, min 24 hours battery recharging capability while under load
12. -48 VDC Battery (Plant or Switchyard/Substation) – C&D (flooded) or East Penn Deka Unigy II (VRLA) w/ one-piece base and interlocking cells, min 8 hours carry time
13. -48 VDC Battery (O&M or Admin Building) – C&D (flooded) or East Penn Deka Unigy II (VRLA) w/ one-piece base and interlocking cells, min 8 hours carry time

1.2 SCADA System-Local Data Collection

1.2.1 General

A. Contractor will provide suitable space, power, and environment control to house the PGE equipment necessary to facilitate the collection of plant control system data.

1. In addition to the Telecommunications, IT Operations, and Physical Security communication racks, Vendor will also provide space for Owner to install (1) 30” x 42” x 84” fully-enclosed, lockable, 4-post network cabinet with venting doors in either the O&M communication room or the Substation.
2. Cabinet shall be installed with 36” clearance in rear of cabinet and 42” in the front. 36” clearance must also be allocated on the sides of the cabinet unless adjacent to another cabinet or communications rack.
3. Vendor shall supply and install fully redundant HVAC systems and humidity control in whatever location the houses the Data Collection Cabinet, with sufficient cooling for all equipment in that location.
4. Vendor shall provide (1) 30A, 240V circuit to each cabinet.

1.2.2 SCADA Hardware and Software Requirements

A. Contractor will provide the following equipment for Owner’s data collection system. Contractor will install all equipment in the provided cabinet in coordination with Owner at least 90 days prior to Substantial Completion. Once installed, Contractor will turn over all equipment and licenses to Owner for configuration.

B. Owner will have final approval on what hardware and software is provided to ensure system operations. If the specific devices below are not available or if the OEM has announced any end of support for the hardware or software, Owner will provide equivalent models for the Contractor to procure (at Contractor's cost).

a. 1x AR3150 (APC NetShelter SX 42U Deep Rack Enclosure) with 2x AR3150 (0U PDU mounts) and 1x AR7714 (rack roof brush strip)

b. 1x 4-node Dell VxRail Custer (E660F or newer). Each server should be single-socket with an Intel Xeon 6346 or better with 256GB RAM and 4-port SFP28 network card. Storage should be all-flash with a total usable space of 20TB, with the ability to expand to at least 45TB in the future.

c. 2x Cisco C9300X-48TX (or newer) with C9300X-NM-8Y and stack cables with 5-year DNA license

d. 16x Cisco SFP-10/25G-CSR-S= Transceivers

e. 8x Dell-compatible 10BASE-T SFP+ Copper RJ45 Transceivers

f. 2x Cisco FPR-1120 (or newer), with 5-Year Malware and Threat licenses

g. 1x Eaton 9PX8KSP

h. 2x Schneider AP8870

i. 1x Black Box LES1516A

j. 1x Recessed 19" rack-mounted DIN Rail with terminal blocks and 30A 2-pole breaker

k. 1x 1U Mixed-use (copper & fiber) feed-through patch panel

l. Software and Licenses:

i. All server cluster fully licensed with vSphere Enterprise Plus and vSAN (version 8 or newer)

ii. Windows Server 2022 (or newer) Datacenter licenses for all CPU Cores

iii. 2x Microsoft SQL Server 2019 (or newer) Standard licenses

iv. Emerson Ovation Green (MiScout) data collector software, configured in High Availability mode, with sufficient licenses for provided system.

C. Contractor, in coordination with OEM SCADA Vendor, shall:

1. Make available all datapoints within the OEM SCADA System to the Owner, including individual tower/panel/battery values, directly from the OEM SCADA System to PGE's Data Collection system.

   a. If PGE is responsible for day-to-day maintenance or control of the plant, this system shall have read/write access to the OEM SCADA System and act as an overlay-SCADA from which operators can use to manage and control the facility.

   b. If PGE will not be responsible for any day-to-day maintenance, the system shall have read-only access.

2. Ensure data values are available in the native resolution in which they were collected, up to 1Hz.

3. Configure the OEM SCADA system to allow Owner data collection system to pull all live, historical, and alarm data using one or more of the following methods:

   a. OPC UA

   b. UPC DA

   c. ODBC

   d. Direct queries to tower controllers using native protocol

1.3 METERING and TELEMETRY FACILITES

1.3.1 GENERAL

A. PGE requires one owner per Point of Interconnection.

1.3.2 DIRECT TELEMETRY REQUIREMENTS

A. PGE requires two communication paths for controlling and operating generation that is settled within its Balancing Authority Area:

1. Direct, real-time telemetry (SCADA) from RTU (site) to RTU (PGE control center)

2. ICCP over WECC Operations Network (WON)

1.3.3 METERING REQUIREMENTS

A. PGE requires primary and backup metering for each metered point. Meters shall be sourced from wound-type instrument transformers for voltages 230kV and below. Meters shall be accessible via PGE's MV90 system for accounting purposes.

1.4 PROCESS DATA FOR PATTERN RECOGNITION

As a minimum, Contractor shall install instrumentation and make the process data available to access by Owner in the Plant's Control System for following systems and equipment (as applicable):

1.4.1 Hydro Turbine

A. Turbine Guide RTD
B. Lower Guide RTD
C. Upper Guide RTD
D. Thrust Bearing RTD
E. Lube Oil Pressure
F. Lube Oil Temperature
G. Gen Turbine Local Ambient Temp
H. Turbine Guide Bearing X VIBR
I. Turbine Guide Bearing Y VIBR
J. Upper Guide Bearing X VIBR
K. Upper Guide Bearing Y VIBR
L. Lower Guide Bearing X VIBR
M. Lower Guide Bearing Y VIBR
N. Wicket Gate Position
O. Wicket Gate Pressure
P. Cooling Water Pressure
Q. Cooling Water Temperature
R. Forebay Level
S. Tailrace Level

1.4.2 Wind Turbines

A. Pitch - Blade A/B/C Pitch Motor Current
B. Pitch - Blade A/B/C Pitch Motor Voltage
C. Pitch - Blade A/B/C Pitch Position
D. Pitch - Blade A/B/C Hydraulic Oil Accumulator Pressure
E. Pitch - Pitch Pressure Output From Hydraulic Power Unit
F. Pitch - Pitch Oil Temperature - Outlet Hydraulic Power Unit
G. Pitch - Pitch Oil Accumulator Temperature
H. Pitch - Pitch Controller Panel Temperature
I. Pitch - Pitch Bearing A/B/C Vibration
J. Hub - Hub Temperature
K. Hub - Ice Detection System
L. Main Bearing(S) - Main Bearing Temperature
M. Main Bearing(S) - Main Bearing Vibration

N. Main Bearing(S) Oil Lubrication System - In Line Metal Particle Counter
O. Main Bearing(S) Oil Lubrication System - Oil Filter Differential Pressure
P. Main Bearing(S) Oil Lubrication System - Oil Pump Amps
Q. Main Bearing(S) Oil Lubrication System - Oil Temperatures - Inlet/Outlet Heat Exchanger
R. Main Shaft - Main Shaft Brake Pressure
S. Main Shaft - Main Shaft Brake Accumulator Pressure
T. Main Shaft – Shaft RPM
U. Gearbox – All Bearing Temperatures
V. Gearbox - Gearbox Lube Oil Pressure, Before Filter
W. Gearbox - Gearbox Lube Oil Pressure, After Filter
X. Gearbox - Planetary Vibration
Y. Gearbox - High Speed Shaft Vibration
Z. Gearbox - Intermediate Speed Shaft Vibration
AA. Gearbox - Oil Temperature - Gearbox Sump
BB. Gearbox Oil Lubrication System - In Line Metal Particle Counter
CC. Gearbox Oil Lubrication System - Oil Filter Differential Pressure
DD. Gearbox Oil Lubrication System - Oil Pump Amps
EE. Gearbox Oil Lubrication System - Oil Temperatures - Inlet/Outlet Heat Exchanger
FF. Generator - Winding Temperature 1/2/3
GG. Generator - Generator Drive End Bearing Temperature
HH. Generator - Generator Non-Drive End Bearing Temperature
II. Generator - Generator Drive End Bearing Vibration
JJ. Generator - Generator Non-Drive End Bearing Vibration
KK. Generator - Phase A/B/C Voltage
LL. Generator - Phase A/B/C Current
MM. Generator - Power Factor
NN. Generator - Heat Exchanger Water Inlet/Outlet Temperatures
OO. Generator – Shaft Torque
PP. Generator – Frequency (generator side)
QQ. Generator – Shaft RPM
RR. Generator – Active Power
SS. Generator – Reactive Power
TT. Yaw - Yaw Position
UU. Yaw - Yaw Brake Accumulator Pressure
VV. Yaw - Yaw Brake Pressure
WW. Yaw – Yaw Motor/Gear Temperature
XX. Tower - Wind Speed Primary
YY. Tower - Wind Speed Secondary
ZZ. Tower - Wind Direction
AAA. Tower - Nacelle Temperature
BBB. Tower - Tower Base Temperature

CCC. Tower - Control Panel(S) Temperature
DDD. Tower – Converter Inside Compartment Temperature
EEE. Tower – Converter Coolant Pressure
FFF. Tower – Converter Coolant Temperature
GGG. Tower – Frequency (grid side)
HHH. Tower – Phase A/B/C Voltage (grid side)
III. Tower – Phase A/B/C Current (grid side)
JJJ. Tower - Misc. Panel Cooling System - Inlet/Outlet Temperatures Of Cooling Media
KKK. Tower - Misc. Panel Cooling System - Inlet/Outlet Temperatures Of Panel Air At Cooler
LLL. Tower - Transformer Temperature
MMM. Tower - Ambient Temperature
NNN. Tower – Air Density
OOO. Tower - Sway
PPP. Tower – Error Code
QQQ. Tower – Operational State
RRR. Main Breaker - Status
SSS. Main Breaker - Faults
TTT. Main Breaker - Temperature
UUU. Main Breaker - Fan Ampere
VVV. Meteorological Station - Air Temperature
WWW. Meteorological Station - Cell Temperature
XXX. Meteorological Station - Relative Humidity
YYY. Meteorological Station - Wind Speeds At 10 meter, 1/2 Hub Height, and Hub Height
ZZZ. Meteorological Station - Barometric Pressure
AAAA. Meteorological Station – Air Density
BBBB. Switchgear - Breaker Phase Currents
CCCC. Switchgear - Breaker Phase Voltages
DDDD. Switchgear - Breaker Status
EEEE. Switchgear - Relay Fault Codes
FFFF. Switchgear - Bolted Bus Connections Temperatures via Fiber Optics

1.4.3 PV Field

A. Combiner Box - DC Output Voltage
B. Combiner Box - DC Output Current
C. Combiner Box - DC Current per String
D. Combiner Box - Combiner Box Interior Temperature
E. Inverter - DC Input Voltage
F. Inverter - DC Input Current
G. Inverter - AC Output Voltage
H. Inverter - AC Output Current

I. Inverter - AC Power
J. Inverter - AC Frequency
K. Inverter - AC Reactive Power
L. Inverter - Energy Totalizer
M. Inverter - Inverter Temperatures
N. Inverter - Inverter Status
O. Inverter - Faults/Alarms
P. Inverter - Ground Current
Q. Meteorological Station - Air Temperature
R. Meteorological Station - Cell Temperature
S. Meteorological Station - Relative Humidity
T. Meteorological Station - Wind Speed
U. Meteorological Station - Global Irradiance
V. Meteorological Station - Plane of Array Irradiance
W. Meteorological Station - Solar Module Back Panel Temperature(s) - 10% of Modules
X. Switchgear - Breaker Phase Currents
Y. Switchgear - Breaker Phase Voltages
Z. Switchgear - Breaker Status
AA. Switchgear - Relay Fault Codes
BB. Switchgear - Bolted Bus Connections Temperatures via Fiber Optics

1.4.4 Oil-Cooled Transformers

A. Active Power
B. Reactive Power
C. High Side Amps (by phase)
D. High Side Voltage (by phase)
E. Ground Current
F. Low Side Voltage (by phase)
G. Control Voltage
H. Control Panel Temperature
I. LTC Tap Position
J. Oil Pump Amps
K. Oil Pump Discharge Pressure
L. Fan Bank Amps
M. LTC Tank Oil Temperature
N. Main Tank Oil Temperature
O. Top Oil Temperature
P. High Voltage Winding Temperature
Q. Low Voltage Winding Temperature
R. Nitrogen Pressure
S. Local Ambient Temperature
T. Moisture Percentage

U. Gas Analyzer H_2
V. Gas Analyzer O_2
W. Gas Analyzer N_2
X. Gas Analyzer CO
Y. Gas Analyzer CO_2
Z. Gas Analyzer CH_4
AA. Gas Analyzer C_2H_6
BB. Gas Analyzer C_2H_4
CC. Gas Analyzer C_2H_2
DD. Gas Analyzer H_2O
EE. Infrared Camera Temperatures

1.4.5 Dry Transformers

A. Active Power
B. Reactive Power
C. High Side Amps (by phase)
D. High Side Voltage (by phase)
E. Ground Current
F. Low Side Voltage
G. Low Side Amps
H. Control Voltage
I. Control Panel Temperature
J. Cooling Fan Amps
K. High Voltage Winding Temperature
L. Low Voltage Winding Temperature
M. Local Ambient Temperature

1.4.6 Switchgear / Motor Control Centers

A. Control Panel

1. Control Panel Voltage
2. Control Panel Temperature

B. 4160 VAC and Higher Bus

1. Connected Joints Temperature Via Fiber Optic Infrared Measurement

C. MCC Bucket

1. Load Amps
2. Load Voltage
3. Power Factor
4. Bucket Temperature
5. Cooling Fan Amps

1.4.7 Heat Exchangers

A. Inlet/Outlet Temperatures
B. Process Flows

1.4.8 Pump / Fan Motors Greater than 100 HP

A. Motor Stator Temperature
B. Local Ambient Temperature
C. Motor Amps
D. Motor Power Factor
E. Motor Voltage